Iarnród Éireann
Irish Rail

Rosslare ORE Hub

EIAR Technical Appendices

Technical Appendix 13

Marine Mammals

Report 1:

Desk Study and Surveys

venterra | GDG Gavin & Doherty Geosolutions

Nicholas O'Dwyer an RSK company

Co-funded by the European Union

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

ARC	Activity Requiring Consent
Avg_Power_D	Average Power Density (dB FS/Hz), defined as the power of the call's signal as a function of frequency
BND	Bottlenose Dolphin
CD	Common Dolphin
D	Day
dB	Decibel
Delta_Freq	Frequency Range (Hz), defined as the range of frequencies (Hz) spanned by the call, calculated as: Delta_Freq = High_Freq − Low_Freq
Delta_Time	Duration (s) of the call, calculated as the difference of time between the end point of the call and the start point of the call
DPM	Detection Positive Minutes
EIA	Environmental Impact Assessment
EU	European Union
EEZ	Exclusive Economic Zone
FFT	Fast Fourier Transformation
FS	Full Scale
GDG	Gavin & Doherty Geosolutions Ltd.
GS	Grey Seal
High_Freq	High Frequency (Hz), defined as the frequency (Hz) at the highest point of the call
HS	Harbour Seal
Hz	Hertz

IMBRSea	International Master of Science in Marine Biological Resources
IWDG	Irish Whale and Dolphin Group
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
Low_Freq	Low Frequency (Hz), defined as the frequency (Hz) at the lowest point of the call
MMO	Marine Mammal Observer
MSFD	Marine Strategy Framework Directive
MW	Minke Whale
N	Night
NPWS	National Parks and Wildlife Service
ObSERVE	Marine scientific programme established in October 2014 with the main aim to greatly improve the knowledge and understanding of protected offshore species and sensitive habitats through high quality, state-of-the-art data collection across Ireland's EEZ.
Peak_Freq	Peak Frequency (Hz), defined as the specific frequency at which the call reaches its maximum amplitude or intensity
QI	Qualifying Interest
RD	Risso's Dolphin
SAC	Special Area of Conservation
SAM	Static Acoustic Monitoring
SD	Standard Deviation
SeaMonitor	EU INTERREG VA-funded project, led by the Loughs Agency and supported by another eight leading marine research institutions, which established a number of large scale marine telemetry arrays to track mobile marine fauna in the seas around Northern Ireland, the Republic of Ireland, and the west of Scotland.
Sea state	In visual surveys, sea state refers to the condition of the ocean's surface, primarily influenced by wind and waves, which can significantly affect the

	visibility of marine mammals. The sea state is often described using the Beaufort scale, a system that ranges from 0 (calm, glassy seas) to 12 (hurricane-force conditions). Low sea states (Beaufort 0-2) ensure detection probability is high during visual surveys, as higher sea states can obscure animals at the surface or distort their appearance.
SMRU	Sea Mammal Research Unit
STRAITS	Strategic Infrastructure for Improved Animal Tracking in European Seas. A four-year EU-funded infrastructure project that will instrument all four corners of Europe to monitor the movements of aquatic animals at a pan-European scale.
VP	Vantage Point

13 DESK STUDY AND SURVEYS

13.1 INTRODUCTION

This Technical Report forms **Report 1** of **Technical Appendix 13: Marine Mammals** and has been prepared to accompany **Volume 1: Chapter 13: Biodiversity Marine Mammals** of the Rosslare Europort Development (hereafter the 'Proposed Development') Environmental Impact Assessment Report (EIAR).

Irish Whale & Dolphin Group Consulting (hereafter IWDG) and Gavin & Doherty Geosolutions (GDG) were commissioned by Iarnród Éireann to undertake a desk-based study, a 24-month land-based visual marine mammal Vantage Point (VP) survey and Static Acoustic Monitoring (SAM) to assess the presence and activity of marine mammals in and around Rosslare Europort.

13.1.1 SCOPE OF REPORT

This report provides a comprehensive overview of the methodologies and findings from the desktop study conducted by IWDG and GDG, as well as field surveys completed by IWDG between June 2022 and August 2024. These studies, including acoustic field surveys conducted between December 2023 and July 2024, were undertaken to establish baseline conditions for marine mammal species within the Proposed Development Boundary and its surroundings. Data analyses, including seal vocalisation analysis conducted by GDG, are detailed in Section 13.2.2.3.

13.1.2 STATEMENT OF AUTHORITY

This report is based on work undertaken by Dr Simon Berrow, Nick Veale, Dr Joanne O'Brien, Dr María Pérez Tadeo (all IWDG) and Yaiza Pilar Pozo Galvan (GDG).

Dr Simon Berrow oversaw the data collection process and served as the primary author of the desk study and VP survey results. He has been working on cetaceans (whales, dolphins and porpoises) in Ireland since 1987. He is a founder member and current Chief Science Officer, of IWDG (www.iwdg.ie) which co-ordinate All of Ireland long term recording schemes. The data from these schemes support the development of conservation policies and best practice guidelines for the conservation and management of cetaceans in Ireland.

IWDG Consulting (http://consulting.iwdg.ie) is the commercial wing of the IWDG and is involved in a wide range of projects from provision of Marine Mammal Observers (MMOs) and Passive Acoustic Monitoring (PAM) operators to preparing environmental assessments and carrying out monitoring contracts. Simon is also a lecturer at the Atlantic Technological University, Galway contributing to the Applied Freshwater and Marine Biology degree and a number of Masters programmes and currently supervises four PhD candidates. He has nearly 200 scientific papers in peer-reviewed journals to his name and sits on a number of scientific committees.

Nick Veale served as the surveyor for the Vantage Point surveys. He has 20 years of professional experience in ecology, including over 10 years of expertise working on offshore survey vessels as an ESAS observer and Marine Mammal Observer (MMO). Nick has been a key member of the onshore and offshore Ornithology and Marine Mammal survey teams for numerous Irish offshore renewable energy projects. These projects include the Oriel Windfarm, Dublin Array, North Celtic Sea Windfarm, North Irish Sea & South Irish Sea Windfarm, Arklow Bank Phase 2. In these projects, Nick's roles have encompassed both boat-based surveys as an ESAS and MMO surveyor, as well as land-based vantage point surveys along headlands adjacent to the proposed offshore windfarms. The vantage point surveys focused on marine mammal observations and wildfowl migration patterns. Over the past 10 years, Nick has accumulated hundreds of hours in this role, underpinned by a lifetime of experience conducting headland observations across Ireland and the UK.

Dr Joanne O'Brien conducted the analysis of the SAM data and served as the primary author of the SAM sections. She graduated with an Honours degree in Marine Science from the National University of Ireland, Galway (NUIG), followed by a PhD from Galway-Mayo Institute of Technology (GMIT). Since 2004, she has conducted extensive offshore and inshore marine mammal visual and acoustic surveys aboard Ireland's state research vessels. As work-package leader on the PReCAST project (2009–2011), Joanne was responsible for Static (i.e. static stations, where hydrophones like C-PODs and SoundTraps are deployed in water for a certain period) and Passive (i.e. passive, towed hydrophone) acoustic monitoring and later served as the principal investigator on an EPA-funded project assessing Ocean Noise in Irish waters (2011–2013) and the ObSERVE Acoustic project (2015–2018). Her primary research interests lie in marine mammals, bioacoustics, and the impacts of anthropogenic noise, soundscapes, and habitat modelling. In addition, she is actively engaged in acoustic research across a wide range of freshwater and terrestrial species.

Dr María Pérez Tadeo conducted the ambient noise analysis. She holds a B.Sc. in Marine Sciences (University of Vigo), an international M.Sc. in Marine Biodiversity and Conservation (Ghent University) and a Ph.D. in Aquatic Sciences at the Marine and Freshwater Research Centre in ATU (2018-2022). Her doctoral research was focused on the factors affecting local abundance and behaviour of grey seals (*Halichoerus grypus*) and harbour seals (*Phoca vitulina*) at two sites on the west coast of Ireland (the Blasket Islands and Galway Bay) and its implications for management and conservation. She is a postdoctoral researcher on the EU-funded STRAITS project (Strategic Infrastructure for Improved Animal Tracking) working on passive acoustic monitoring of marine mammals and assessing noise levels at different sites across Europe.

Yaiza Pilar Pozo Galvan (BSc. (Hons) Marine Sciences, International MSc. (Hons) Marine Biological Resources) conducted the seal vocalisation analyses and authored the corresponding sections, as well as prepared the report. Yaiza is an Oceanographer and Marine Mammal Ecologist, specialised in Marine Conservation and Applied Megafauna Conservation. Her research is mainly focused on animal behaviour, telemetry and bioacoustics, working with international teams and being involved in European projects (SeaMonitor, STRAITS). She is also a Joint Nature Conservation Committee (JNCC) certified Marine Mammal Observer (MMO) and currently works for GDG preparing marine licences and environmental assessments. Since September 2024, she has also been pursuing a PhD at the Atlantic Technological University (Galway), continuing her research on seal bioacoustics.

This report has been reviewed by Joey O'Connor (BSc. (Hons) Marine Science, MSc. Engineering in the Coastal Environment). Joey is an Environmental Impact Assessment practitioner and Marine Scientist with coastal engineering expertise and extensive experience of offshore survey and Marine

Protected Area monitoring. Joey has had an overview role in this project as EIAR coordinator and Biodiversity Lead.

This report has been peer-reviewed by Dr. Laura Williamson from HiDef. Laura joined HiDef in August 2024 to lead Environmental Impact Assessments (EIAs) and Habitats Regulations Appraisals (HRAs) for marine mammals, underwater noise, and seabirds. She has a strong background in marine mammal ecology and risk mitigation, as well as survey design, data analysis, and reporting for the offshore wind sector. Prior to joining HiDef, Laura worked at Ocean Science Consulting Limited for six years, beginning in an R&D role before progressing to Head of Projects, where she was responsible for project management, business strategy, tendering and grant writing, quality assurance of reports and publications, as well as staff and student supervision and mentoring. During her MRes and PhD at the University of Aberdeen, Laura analysed data from echolocation-click detectors (C-PODs), as well as HiDef digital aerial video footage to investigate the distribution of harbour porpoise along the east coast of Scotland.

13.1.3 SITE OVERVIEW

The Proposed Development Boundary is located on the southeast coast of Ireland, in the coastal town of Rosslare Harbour, County Wexford. Iarnród Éireann aims to develop port infrastructure, mostly within the marine area adjacent to and just north of the existing Rosslare Europort.

Currents in the study area are affected by local wind conditions overlying northward tidal streams with seasonal stratification in the north contrasting with more mixed oceanographic conditions to the south (Neil *et al*., 2012). A seasonal front has been identified forming in summer from the study area eastward to the coast of Wales (Simpson & Hunter, 1974) and this complex oceanography of the Irish Sea where it borders with the Celtic Sea acts to enhance primary productivity (Raine *et al.,* 1993).

13.2 METHODOLOGY

The ecological studies conducted by IWDG Consulting and GDG presented in this report consists of three key components:

- Desk study review
- Vantage point species surveys
- Acoustic monitoring for noise, cetaceans and pinnipeds.

A detailed methodology for each component is provided in the following sections.

13.2.1 DESK STUDY REVIEW

A desktop review was completed to identify relevant marine mammal species of ecological importance within the Proposed Development Boundary and the surrounding region. This involved a comprehensive review of available, published academic and grey literature related to the Site's ecology, identifying the marine mammal species typically found within or near the Site, as well as the Site's proximity to nature conservation areas where marine mammals are designated for protection.

13.2.1.1 KEY SOURCES

The following key sources were consulted:

- Carter *et al*. 2022 - https://marine.gov.scot/maps/2029
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- National Parks and Wildlife Service. Maps and data. NPWS.ie; available at https://www.npws.ie/maps-and-data
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- Waggitt, J.J., Evans, P.G.H., Andrade, J., *et al*. (2020) Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology, 57, 253–269. https://doi.org/10.1111/1365-2664.13525 000781_Rev15.Docx
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- NPWS (2019a). The Status of EU Protected Habitats and Species in Ireland. Volume 3: Species Assessments. Unpublished NPWS report. Edited by: Deirdre Lynn and Fionnuala O'Neill.
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- Morris, C.M., & Duck, C.D. (2019) Aerial thermal-imaging survey of seals in Ireland, 2017 to 2018. Irish Wildlife Manuals, No. 111 National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Ireland.
- Cronin, M., McConnell, B. J., & Rogan, E. (2010). Foraging range, dive behaviour and habitat selection of female harbour seals (Phoca vitulina vitulina) in southwest Ireland. Journal of Zoology, 282(1), 13-26.
- Kiely, O., Ligard, D., McKibben, M., Connolly, N., & Baines, M. (2000). Grey Seals: Status and Monitoring in the Irish and Celtic Seas. Maritime Ireland/Wales INTERREG Report NO.3 The Marine Institute, Ireland.
- Ó Cadhla, O., Strong, D., O'Keeffe, C., Coleman, M., Cronin, M., Duck, C., Murray, T., Dower, P., Nairn, R., Murphy, P., Smiddy, P., Saich, C., Lyons, D., & Hiby, A.R. (2007). An assessment of the breeding population of grey seals in the Republic of Ireland, 2005. Irish Wildlife Manuals No. 34. National Parks & Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.
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- NPWS (2024a) Blackwater Bank SAC Amendment Notification. Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/protected-sites/sac/002953
- NPWS (2024b) Carnsore Point SAC Amendment Notification. Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/protected-sites/sac/002269

13.2.2 FIELD SURVEY METHODOLOGY

13.2.2.1 VANTAGE POINT SURVEYS

Dedicated watches were carried out twice per month between July 2022 and June 2023 (Year 1) and between September 2023 and August 2024 (Year 2) from a watch site to the west of Rosslare Europort (“the port”). As SAM was undertaken to complement watches, SAM locations and visual monitoring watch site and coverage are shown in Figure 13-1.

The VP watches were all carried out by Nick Veale at 52°15'06.9"N, 6°20'56.6"W. The elevation of the VP is approximately 15 m above sea-level. Each watch was 6 hours duration. Each survey day was chosen to coincide with sea conditions with a Beaufort sea state ≤2, swell ≤1 m and good visibility (>10 km). Optical equipment used included 10x50 binoculars and a spotting scope which increased the potential detection range up to 10 km for large cetaceans and 2-3 km for dolphin. The likely detection range for Harbour Porpoise (*Phocoena phocoena*) and seals was around 1 km. During each watch, the area visible was scanned first by the naked eye, then by binoculars and then by spotting scope. Full scans to the horizon (i.e. beyond 10 km range) were carried out every 30 minutes and during each watch any individuals within the detection range were identified, counted and their behaviour recorded.

Note sightings were not recorded in distance bands as it was considered unlikely during survey design that there would be sufficient number of sightings to provide statistically robust density estimates.

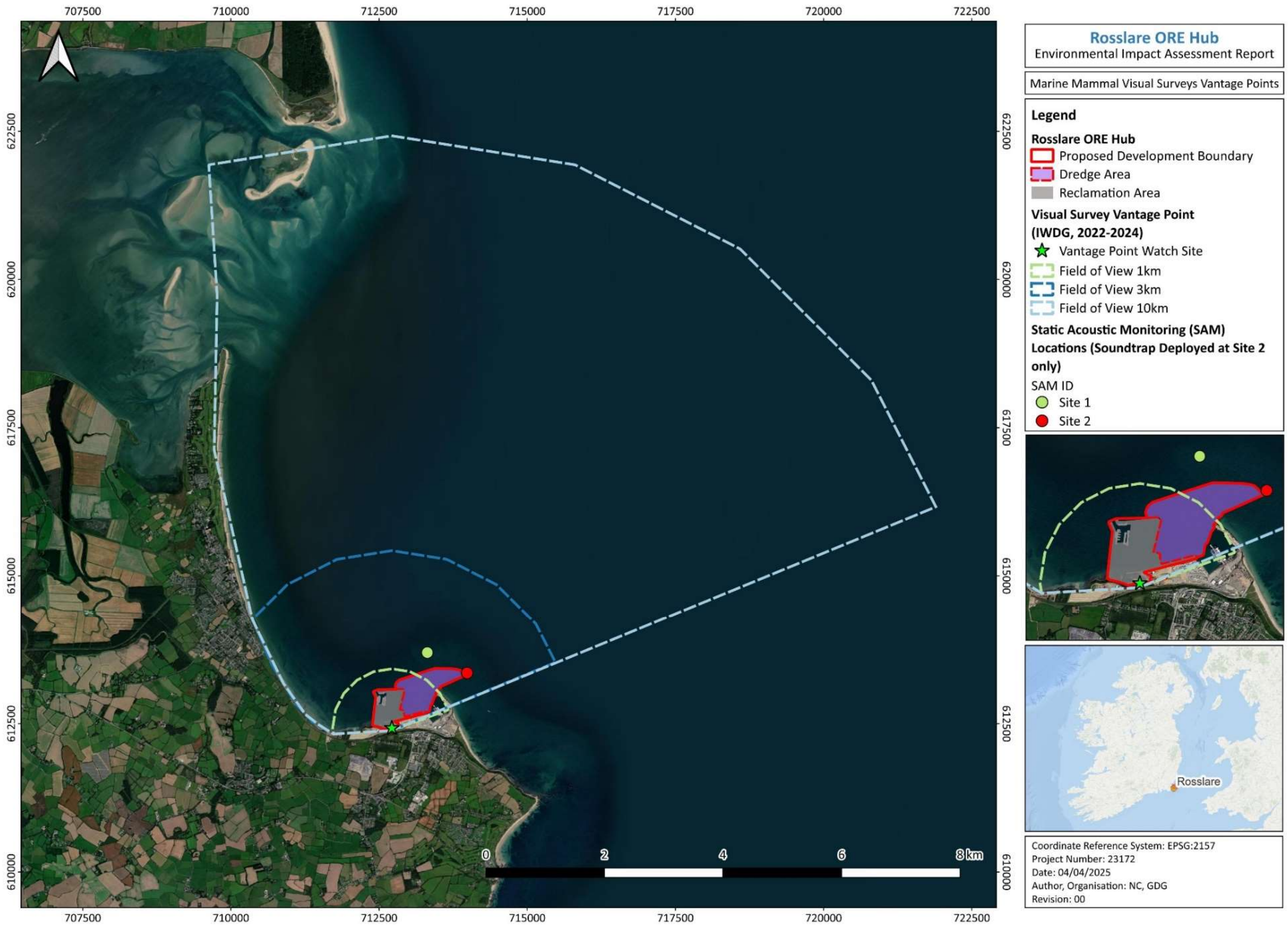


Figure 13-1 VP watch site, detection range Fields of View and Static Acoustic Monitoring deployment locations at Rosslare Europort

13.2.2.2 ORNITHOLOGICAL VANTAGE POINT SURVEYS

Monthly ornithological surveys, also of 6-hour watch duration, were conducted from the same vantage point location by the same surveyor (Nick Veale) as the marine mammal surveys described in this report from April 2022 to September 2024, with opportunistic marine mammal sightings recorded when observed. Please see Technical Appendix 14 for full details of ornithological surveys completed.

While the focus of the ornithological vantage point surveys was on recording birds, marine mammal sightings recorded during ornithological vantage point surveys undertaken in July 2023 and August 2023 are presented in this report for context, as no dedicated marine mammal vantage point surveys were conducted during these months.

13.2.2.3 STATIC ACOUSTIC MONITORING SURVEYS

Static Acoustic Monitoring (SAM) was carried out as part of data gathering to inform the Environmental Impact Assessment process for the proposed Rosslare Europort ORE Hub project (i.e. the Proposed Development).

SAM was used to:

1) acoustically monitor the site and collect long-term robust data from which to assess cetacean presence and site usage
2) establish baseline noise levels at the site

determine the presence of seals The SAM programme was undertaken at two locations using F-PODs to assess the presence of harbour porpoises and dolphins between 14th December 2023 and 28th December 2024 in the Study Area immediately north of Rosslare Europort (Site 1 and Site 2; Figure 13-1). SAM was conducted to complement land-based visual monitoring, as outlined in Section 13.2.2.1 (Berrow & Veale, 2024).

Monitoring was conducted for a total of 377 days at Site 1 and 286 days at Site 2. The shorter deployment period at Site 2 was due to the F-POD not being retrieved during the final site visit in September 2024, as it was no longer attached to the buoy.

13.2.2.3.EQ. (.1) MOORINGS AND DEPLOYMENT

Two deployment methods were used during the acoustic monitoring period (Figure 13-2; Figure 13-3; Figure 13-4; Table 13-1).

From December 2023 to April 2024, F-PODs were deployed by TechWorks Marine as part of a metocean survey (Figure 13-2). Following this, from April 2024 onwards, both F-PODs and a SoundTrap were deployed by the IWDG using dedicated moorings at the same monitoring locations, (Figure 13-3). The SoundTrap was only deployed at Site 2 between April and July 2024 to record broadband acoustic data.

TechWorks Marine moorings consisted of a lighted surface buoy and 3-tonne anchor weights, deployed in accordance with statutory sanction requirements. F-PODs were attached during the initial deployment at both sites and remained in place for 129 days. Once the metocean survey concluded and the TechWorks Marine moorings were removed, the IWDG deployed new moorings at the same locations.

The IWDG moorings were designed to minimise noise, particularly at Site 2 where the SoundTrap was deployed (72 days). A smaller surface buoy (JFL NAV03 Special Mark) was used, with the acoustic devices mounted on a 15kg plough anchor located approx. 5m from the main buoy (Figure 13-4). A surface marker buoy indicated the position of the SAM and facilitated mooring recovery.

At Site 2, the final mooring configuration included both a SoundTrap and an F-POD, deployed on a Sonardyne LRT acoustic release system with no surface buoy, thereby reducing surface drag noise and potential signal masking (Figure 13-4). All equipment was recovered by 28th December 2024, marking the end of the monitoring period.

Note: the number of days at site 2 is shorter as the F-POD from the final deployment was not retrieved as it was not attached to the buoy when the site visit was carried out in December 2024.

Table 13-1: Summary of deployment details for Site 1 and 2, details of devices deployed at each site, and dates deployed recovered

Deployment #	Date deployed	Site 1	Site 2	Date recovered
		[redacted]	[redacted]	
1	12-Dec-23	F-POD	F-POD	20-Apr-24
2	21-Apr-24	F-6908	F-POD /SoundTrap	02-Jul-24
3	02-Jul-24	F-POD	F-POD	28-Sep-24
4	28-Sep-24	F-POD		28-Dec-24

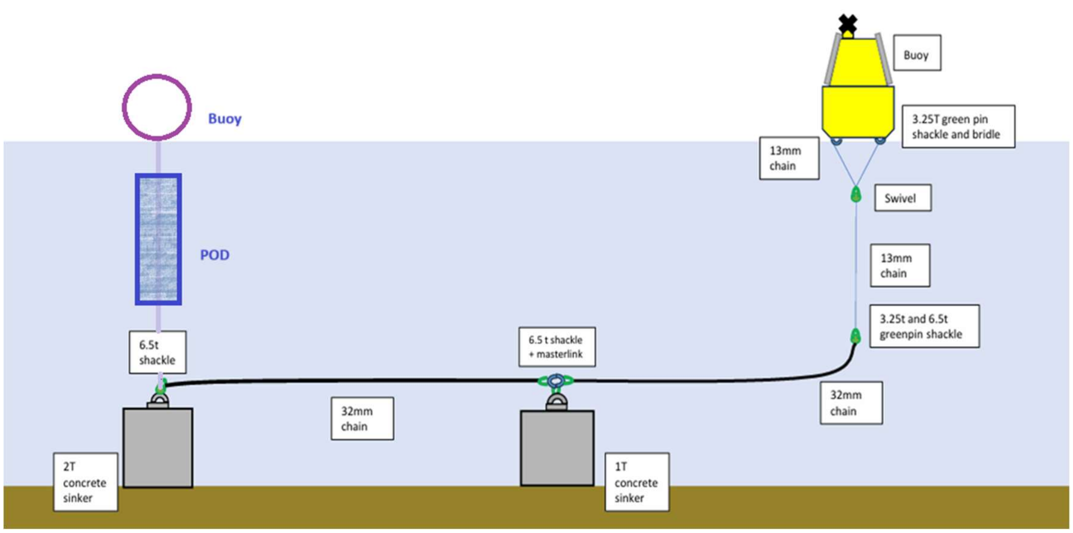


Figure 13-2 Mooring used by TechWorks Marine for deployment of F-PODs

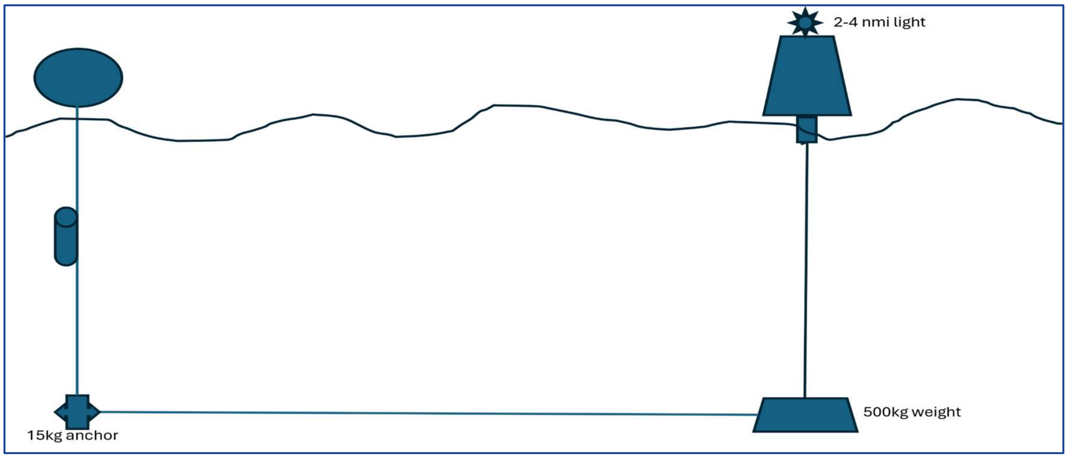


Figure 13-3 Mooring used by IWDG for the deployment of F-PODs (Site 1)

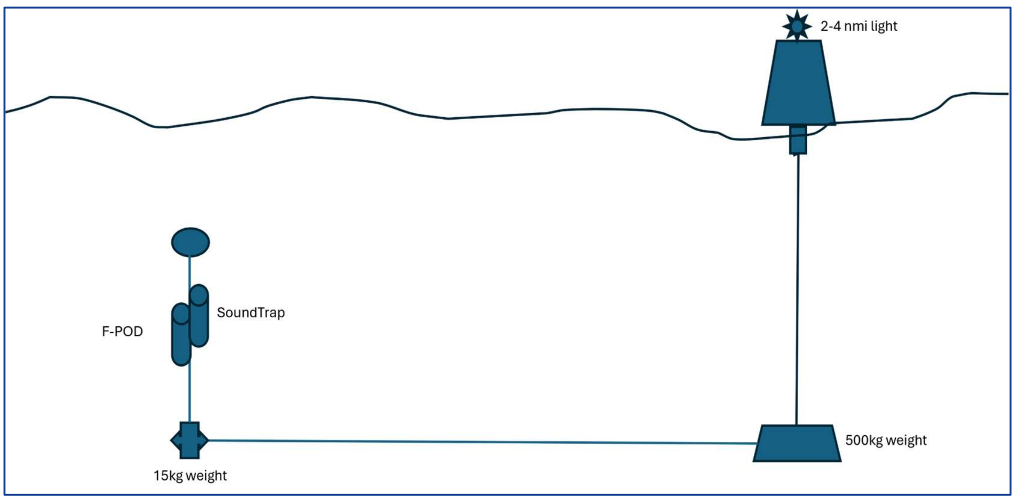


Figure 13-4 Mooring used by IWDG for deployment of F-PODs and SoundTrap at Site 2 on acoustic release to ensure no self-noise from the mooring

F-PODs

The F-POD (Figure 13-5) is a fully automated, SAM system which can detect porpoises, dolphins and other toothed whales by recognising echolocation click trains these animals make to detect their prey, orientate themselves and interact with one another. These units ("F" signifying full waveform capture) are designed and manufactured by Chelonia Ltd, and they were, at the time of deployment, the only commercially available instruments with click train recognition software which produces fully automated, accurate data on the feeding behaviour and identification of odontocetes (see www.chelonia.co.uk).

A single F-POD can monitor both porpoise and dolphins simultaneously through identifying characteristic click parameters which can be assigned to either harbour porpoise or dolphin groups.

These data can be analysed as Detection Positive Minutes (DPM) to generate an acoustic index of presence. DPM's provide an index of seasonal, diel, and tidal occurrence.

The F-POD is the fourth generation POD. The F-POD's performance is based on automatic analysis of click waveform data. Fast Fourier Transform (FFT) analysis of longer clicks is carried out through FPOD.exe software where results can be reviewed and exported. The F-POD does not record actual sound files, only information about the tonal clicks it detects.

Figure 13-5 F-POD by Chelonia

The F-PODs used are sound pressure level detectors with a threshold of 1Pa peak to peak at 130 kHz. An estimated detection distance of 800m for C-PODs (predecessors of F-PODs) and bottlenose dolphins was generated in the Shannon Estuary, while distance estimates of approx. 300m were generated for the harbour porpoise in Galway Bay (O'Brien *et al.,* 2013). These distances are assumed to be similar for the F-POD but in fact may be greater given the F-POD has been found to outperform the C-POD by a rate of at least 40% (Todd *et al*., 2023).

SoundTrap

SoundTraps (ST600 HF, Ocean Instruments NZ, Figure 13-6) are self-contained, autonomous underwater sound recorders designed for long-term deployments. The ST600 has low power consumption, high audio fidelity due to low self-noise, and a wide 150 kHz bandwidth (Ocean Instruments^{NZ}). These broadband acoustic devices can capture a broad range of frequencies, making them suitable for monitoring a wide variety of marine species and environmental sounds, including seals, baleen whales, dolphin whistles, echolocation clicks, and soundscapes.

The ST600 records audio files in .wav format, with adjustable sampling rates and duty cycles to meet different monitoring requirements. Additionally, the SoundTrap ST600 HF is equipped with an integrated click detector capable of processing up to 576 kHz, generating .blc files that can be analysed in the PAMGuard software (PAMGuard, 2024) using a dedicated module. Data collected by SoundTraps can be processed using various software tools including PAMGuard, Raven, and Audacity.

Figure 13-6 SoundTtrap from Ocean Instruments NZ

Calibration

Calibration of equipment is important to allow for comparison of results across units. The manufacturer, Chelonia LTD, calibrates all F-POD units to a standard prior to dispatch. These calibrations are carried out in the lab under controlled conditions and thus Chelonia highly recommends that further calibrations are carried out in the field prior to their use in monitoring programs instead of further tank tests. Field calibrations are important where projects employ several units aimed at comparing detections across several sites. If units of differing sensitivities are used, then these data do not truly reflect the activity at a site. For example, a low detection rate may be attributed to a less sensitive F-POD, with a lower detection threshold, which in turn leads to a lower detection range, while the opposite holds for a very sensitive unit. It is fundamental that differences between units are determined prior to their deployment as part of any project, to allow for the generation of correction factors which can be applied to the resulting data (O'Brien *et al.,* 2013).

F-PODs were calibrated in pairs in the field by IWDG prior to use for the SAM programme for the Proposed Development. Upon recovery of the units, data were extracted under two categories, 1) Narrow Band High Frequency (NBHF) (porpoise band) and 2) Other (dolphin band) using the FPOD.exe software. These data were in the form of Excel.xlsx files using F-POD.exe software and analysed as DPMs across hourly segments. Statistical analyses were carried out using the program R (R Core Team, 2024). All combinations of F-POD pairs were modelled using an orthogonal regression of DPM across hourly segments.

This was compared to a null model, assuming no variation in F-POD detections, a = 0 and b = 1, and used to assess F-POD performance. An error margin of ±20% DPM per hour was plotted along the null model to distinguish between an acceptable level of variation in F-POD performance and problematic variation due to faulty or highly sensitive units. From these graphs it is possible to determine successful or unsuccessful F-POD combinations. The mean intercept and gradient values of the orthogonal model for each F-POD pair were extracted and used to create centipede plots where deviation from 0 on the horizontal axis, of mean intercept values and deviation from 1 on the horizontal axis, of mean gradient values indicated deviations from the null model. This was also used to identify if only one or two POD combinations were unsuccessful and also the extent of variability within the intercept and gradient values. Results were then used to highlight poor performing units or very sensitive units, if they existed, and a correction factor can be generated and applied to the data. All F-PODs used during the present study were found to perform similarly and no issues were detected during tests or calibration trials.

SoundTraps can be calibrated in the lab using a pistonphone but also by using a calibration value provided by the Manufacturers, Ocean Instruments NZ, which is specific to the serial number of each individual device. A 3-second calibration tone was inserted into each .wav file to ensure devices were performing as expected. Additionally, calibration checks prior to deployment showed no issue with the equipment.

SAM Data Analyses

All F-POD data were analysed to extract high-probability clicks (using the F-POD quality categories Hi" and "Mod"). Both dolphin and porpoise detections were extracted as DPM's per day. As recommended by the manufacturers, a validation overview was carried out on the data, where 10%

of all detected trains were visually inspected on F-POD.exe to verify if they were in fact of cetacean origin. Analysis of detections can be carried out across categories: season (spring, summer, autumn and winter), diel cycle (day and night-time), tidal state (ebb, flood, slack high, slack low) and tidal phase (spring, neap). As the F-POD dataset is of six months duration, data are presented in DPMs per day for dolphins and porpoises to provide information on presence of dolphins and porpoise over this time period.

13.2.2.3.EQ. (.2)DATA COLLECTION OF AMBIENT NOISE

Underwater broadband sound was recorded off Rosslare Europort using a SoundTrap ST600 HF (Ocean Instruments NZ: https://www.oceaninstruments.co.nz/product/soundtrap-st600-hf-long-term-recorder/), serial no. 6497, calibrated with an end-to-end sensitivity of 176.3 dB re. 1 µPa. The device was deployed at N52 15.505, W-6 19.813 (Site 2) at a depth of 7m for 72 days, from April 21 to July 2, 2024, acquiring 804 hours of recordings. The SoundTrap was configured to sample at 96kHz for 30 minutes every hour, capturing acoustic data within the 0-48kHz frequency range.

13.2.2.3.EQ. (.3)AMBIENT NOISE ANALYSIS

SoundTrap data can be analysed using a suite of software including R, PAMGuard, dBWav, etc. to extract noise data across a range of frequencies to assess the background noise at the site and to identify noise sources that are most prominent.

Underwater acoustic data were extracted as .wav files from April 26, 2024, to July 1, 2024, and the first 3 seconds of each file, corresponding to the calibration tones, were discarded. Subsequently, the first 15 minutes of each of the 1,739 .wav files were extracted for further analysis. This selective extraction aimed to optimise and speed up the soundscape assessment while still ensuring comprehensive coverage of the recording period.

Ambient sound levels, as Sound Pressure Levels (SPLs) in dB re 1 µPa were quantified in 1/3-octave bands (Hanning window, 0% overlap, 1 second resolution) in the statistical software RStudio (version 4.3.3, February 2024) using the Third-Octave Level (TOL) function from the sound analysis PAMGuide package from Merchant *et al*. (2015) as in Van Geel *et al*. (2022). Daily average SPLs were quantified across the 0-48 kHz frequency range. Subsequently, trends in average SPLs within the 1/3 octave bands 63Hz and 125Hz (centre frequency) were examined further as recommended under the Marine Strategy Framework Directive (MSFD; Dekeling *et al*., 2015; Picciulin *et al*., 2016). These frequency bands are commonly used to assess potential impacts on marine mammals (Merchant *et al*., 2012; Van Geel *et al.*, 2022).

The software Raven Pro was used to visualise acoustic files and the software dBWav (version 1.3.5) developed by Marshall Day Acoustics (https://marshallday.com/dbwav) was used to produce spectrograms and plot 1/3 octave bands of selected wav. acoustic files.

Further analyses of Soundtrap data undertaken are described in the following sections.

13.2.2.3.EQ. (.4)SEAL VOCALISATION PROCESSING

The recorded audio files were decompressed through SoundTrap Host software (version 4.0.19; available at https://www.oceaninstruments.co.nz/downloads/; accessed on 17th September 2024) and the resulting .wav files were processed in PAMGuard, version 2.02.10 (Gillespie *et al.,* 2009). To do so, data were down-sampled to 5 kHz with a decimator, and a low-frequency Fast Fourier

Transformation (FFT) module with a FFT length of 512 and FFT Hop of 256 and a whistle and moan detector with a maximum frequency of 5 kHz were selected. The processed data were then explored in PAMGuard Viewer Mode (Figure 13-7) and detections were manually annotated in Raven Pro, version 1.6.5 (Lisa, 2023), which was set to show spectrograms at FFT resolution of 2,456 bands (window size), a maximum frequency of 5,000 Hz and time resolution of 10 s (Figure 13-8). Spectrogram brightness and contrast were set to 50 and 53, respectively, but modified when needed depending on the file. The type of window selected was Default 1.3 Power. Different parameters were extracted per vocalisation: low frequency (Hz), high frequency (Hz), duration (s), frequency range (Hz), peak frequency (Hz) and average power density (dB FS/Hz); following the approach used by Hanggi & Schusterman (1994), McCreery & Thomas (2009) and Pérez Tadeo *et al.* (2023).

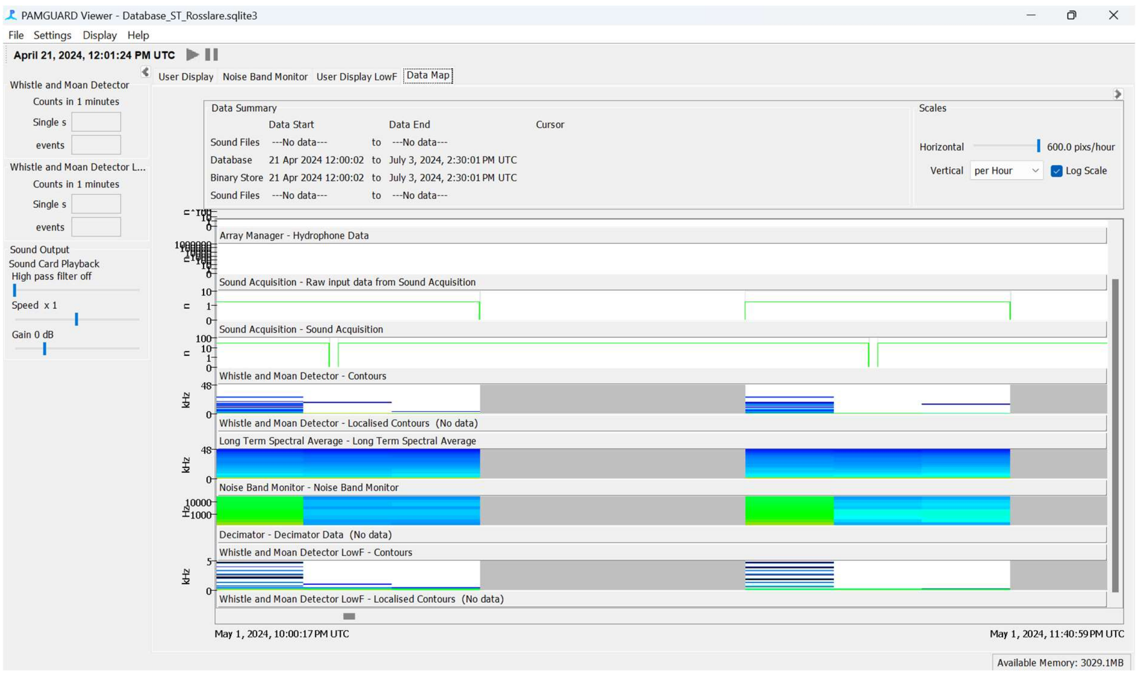


Figure 13-7 Noise Band Monitor and Low Frequency Contours were used for data exploration on PAMGuard Viewer Mode

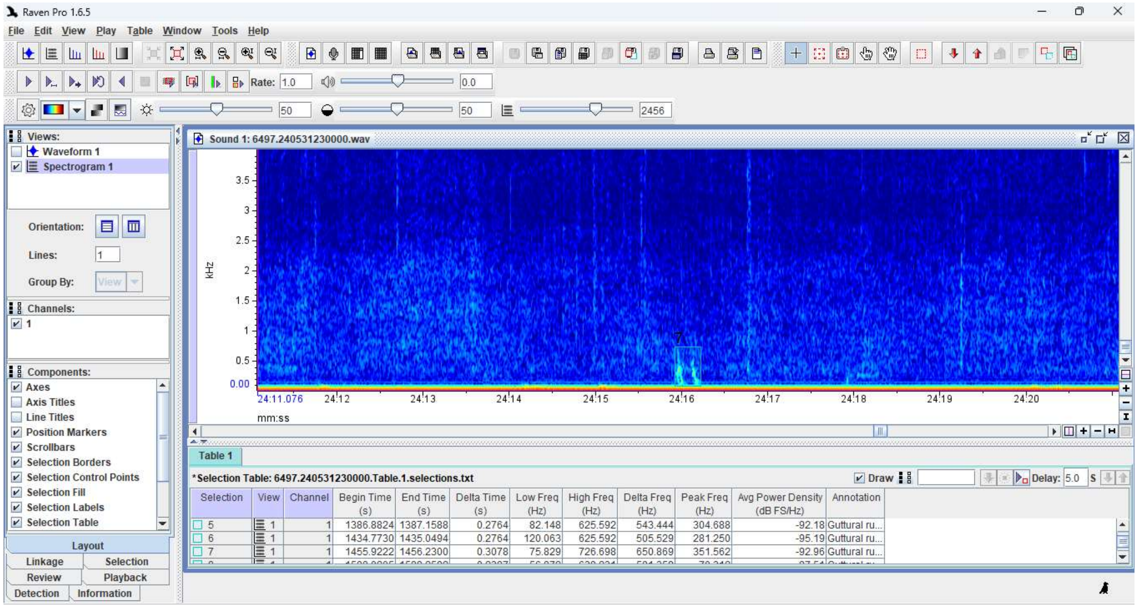


Figure 13-8 Manual extraction of seal vocalisations and their acoustic parameters in Raven Pro

13.2.2.3.EQ. (.5)SEAL VOCALISATION ANALYSIS

Harbour and Grey Seal vocalisations were manually classified based on aural and visual features such as shape, frequency and call descriptions given by previous studies (Asselin *et al*., 1993; Hanggi & Schusterman, 1994; Khan *et al*., 2006; McCulloch, 2000; Nikolich, 2015; Pérez Tadeo *et al*., 2023; Pozo Galván *et al*., 2024; Renouf, 1984). In this way, ten and seven different categories were defined for grey and harbour seals, respectively (Appendix C). New Grey Seal call subtypes, "Rupe D" and Type 4C, were defined in the present study for the first time. Following a similar approach described by Pérez Tadeo *et al*. (2023) and Pozo Galván *et al*. (2024), two-part calls such as "Rupe C" (Type 2C) and Type 5 as well as multiple element vocalisations like "Guttural rupe" (Type 1), "Cry" (Type 9) and "Pop" (Type 10) were selected as a single detection.

Mean and standard deviations of each call parameter were calculated in RStudio, version 4.4.1 (R Core Team, 2024), as well as the proportion of vocalisations per call type (Appendix C). In order to assess the possible influence of diel (day/night), month and tidal states (ebb, flood, high, low) in the vocal behaviour of the species, sunrise and sunset hours were extracted per recording date (https://www.timeanddate.com, accessed on 15th October 2024) and sea surface height was downloaded from Copernicus Marine Environment Service (http://marine.copernicus.eu, accessed on 22nd January 2025). In RStudio, day was defined as the time span between one hour before sunrise and two hours before sunset, and night was defined as the time span between one hour before the sunset and two hours before the sunrise (Pérez Tadeo, 2022; O'Brien, 2013). Sea surface height (tidal elevation) was used to calculate high and low tides with VulnToolkit R package, version 1.1.4 (Hill & Anisfeld, 2021). These values were then used to calculate and classify tidal states as high (H), low (L), ebb (E, between high and low tide) and flood (F, between low and high tide) in RStudio, following the methodology employed by Pozo Galván *et al*. (2024) and O'Brien (2013).

13.3 RESULTS

13.3.1 DESK STUDY REVIEW

13.3.1.1 MARINE MAMMALS IN IRISH WATERS: LEGAL FRAMEWORK AND NOISE IMPACTS

All cetacean (26 species) and pinniped species (2 breeding species) occurring in Irish waters are protected across a suite of national (Whale Fisheries Act of 1937 and the Wildlife Acts 1976 to 2018, and recent amendments) and international legislation (e.g. European Habitats Directive (1992/43/EC), transposed into national legislation by the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011) and indirectly through the Marine Strategy Framework Directive (MSFD, 2008/56/EC). Within this legal framework, any potential disturbance from anthropogenic activity should be carefully assessed to understand potential impacts and inform mitigation measures, if necessary, to reduce any long-term impacts to acceptable levels.

Marine mammals are one of the more sensitive groups to anthropogenic sound as they have a highly developed auditory system and actively use sound for feeding and social communication. Marine mammals can be impacted by noise directly through hearing impairment (Temporary or Permanent Threshold Shift: TTS or PTS), or indirectly by impacting their prey species (Gordon *et al.,* 2003). Other effects include physiological changes such as the production of stress responses, behavioural alterations through avoidance and displacement, changes in vocalisations, or masking of their own acoustic signals (Weilgart, 2013; Erbe *et al*., 2019; Duarte *et al.,* 2021).

Shipping and pile driving are two of the most significant sources of continuous and impulsive anthropogenic noise sources in Irish waters. Pile driving strikes have generally been reported to produce low-frequency pulse sounds of several tens of Hz to several thousand Hz (and up to approximately 20 kHz; Richardson *et al.,* 1995). This presents the possibility of PTS or TTS for some marine mammals in close proximity to such operations. Due to the low frequency and high source level of piling noise (>120 dB re: 1 µPa), it can propagate long distances, with potential to be detected above ambient noise at over 10 km (Richardson *et al.,* 1995; Guan & Miner, 2020); therefore, potentially causing significant behavioural disturbance to marine mammals at distances of several kilometres (e.g. 14km for harbour porpoise (van Geel *et al*., 2023)). As pile driving tends to take place in a fixed area for a prolonged period of days or weeks, depending on the required scale of development, it has the potential to introduce prolonged anthropogenic sound at levels that may impact individuals and populations of marine mammals.

The effects of shipping noise on marine mammals are not a recent phenomenon but have been raised for decades (Erbe *et al.,* 2019). Noise from shipping peaks in low-frequency bands, and early studies focused on mysticetes, since all their sound production overlaps these low frequencies, but ships also emit significant energy at higher frequencies (tens of kHz) and so odontocetes (i.e., toothed whales, dolphins, and porpoises) can also be affected (Erbe *et al.,* 2019).

To ensure that significant marine developments comply with both Ireland's environmental and conservation commitments and with the legislation in place, it is essential that these developments are conducted after thorough EIA, to establish the potential risk to marine mammals and their habitats. Information regarding the abundance, temporal and spatial distribution, and habitat use of protected species, including seals, dolphins and harbour porpoise, is important if they are known to occur in the area. Underwater acoustic techniques are powerful and cost-effective tools to monitor marine mammals (Mellinger, 2007).

13.3.1.2 CETACEANS (WHALES, DOLPHINS AND PORPOISES)

The most recent broad-scale survey available was carried out by Giralt Paradell *et al*. (2024) as part of Phase II of the ObSERVE project, building upon the groundwork established in Phase I by Rogan *et al.* (2018). Surface density maps were presented for the whole of the Irish EEZ. Surveys were carried out from a Partenavia P-68 fixed-wing aircraft flying at a speed over the ground of 90-100 knots (167-185 km/hr) and an altitude of 600 feet (183 m) above the sea surface.

Harbour Porpoise were the most frequently recorded species off the southeast of Ireland both during summer and winter (Figure 13-9). Density estimates from the model-based approach were 0.4158 (summer 2021), 0.262 and 0.379 (summer and winter 2022, respectively) porpoises per km^2 (Giralt Paradell *et al*., 2024).

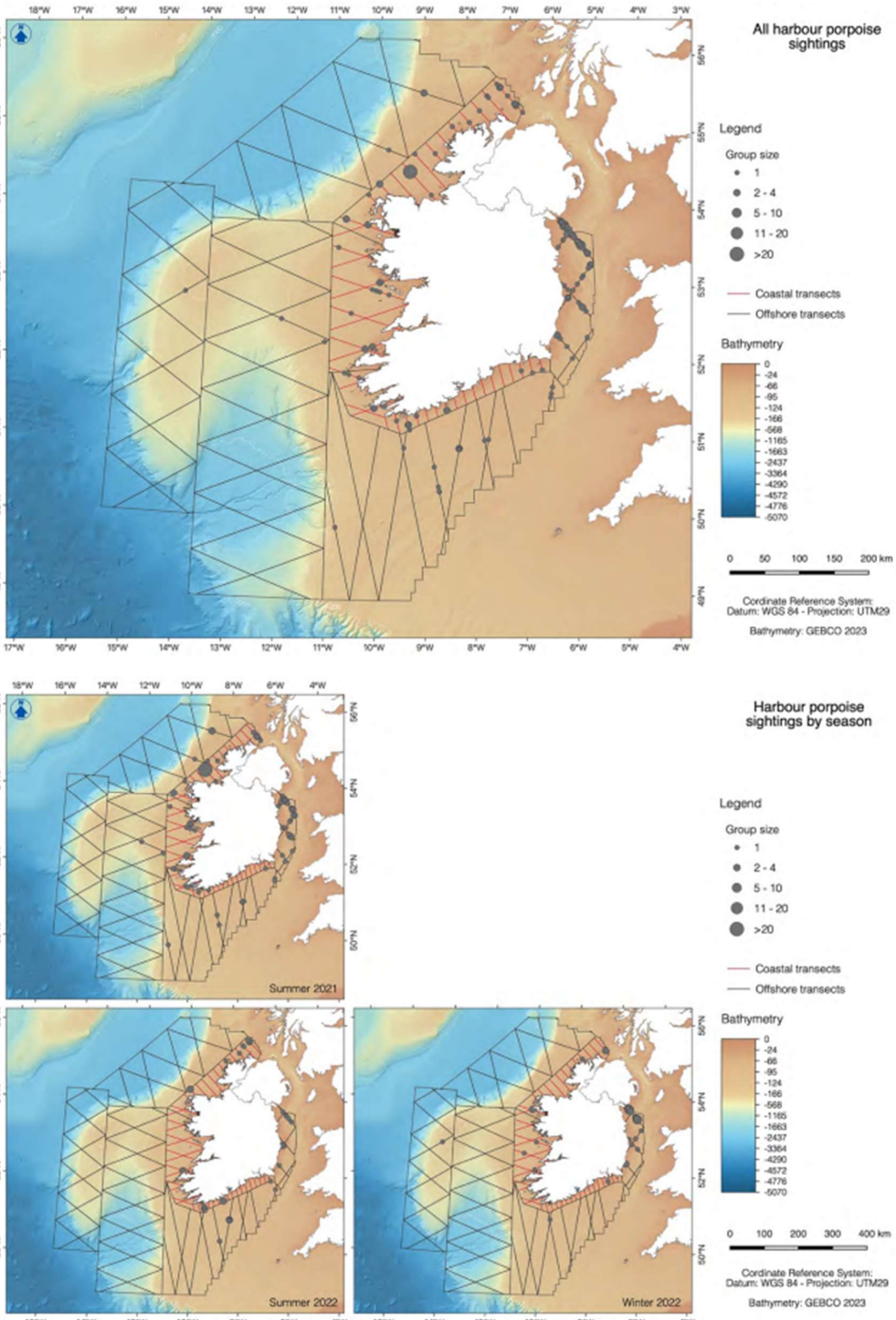


Figure 13-9: Harbour Porpoise sightings during Phase II of the ObSERVE Aerial Surveys carried out in summer and winter 2021 and 2022. Note that no surveys were carried out in winter 2021. Grey lines indicate the survey track lines in the offshore strata and red lines indicate the track lines in the coastal strata. Circles are proportional to the number of porpoises in each sighting (from Giralt Paradell *et al.*, 2024).

The Phase I of the ObSERVE Aerial surveys (2015-2017) also found the Irish Sea to be an important area for Harbour Porpoise across all seasons (Figure 13-10), with higher densities in this area compared to other strata. Density estimates from the model-based approach were higher than those recorded during Phase II, with 0.675 and 0.942 porpoises per km^2 in summer 2015 and 2016, respectively (there were too few sightings of this species to generate model-based density distributions in each winter survey period). The only other species recorded off the southeast coast (stratum 5) were Risso's Dolphin (*Grampus griseus*), which were recorded twice, one in each summer survey period (2015 and 2016). No density estimates were attempted due to the low number of sightings (Rogan *et al*., 2018).

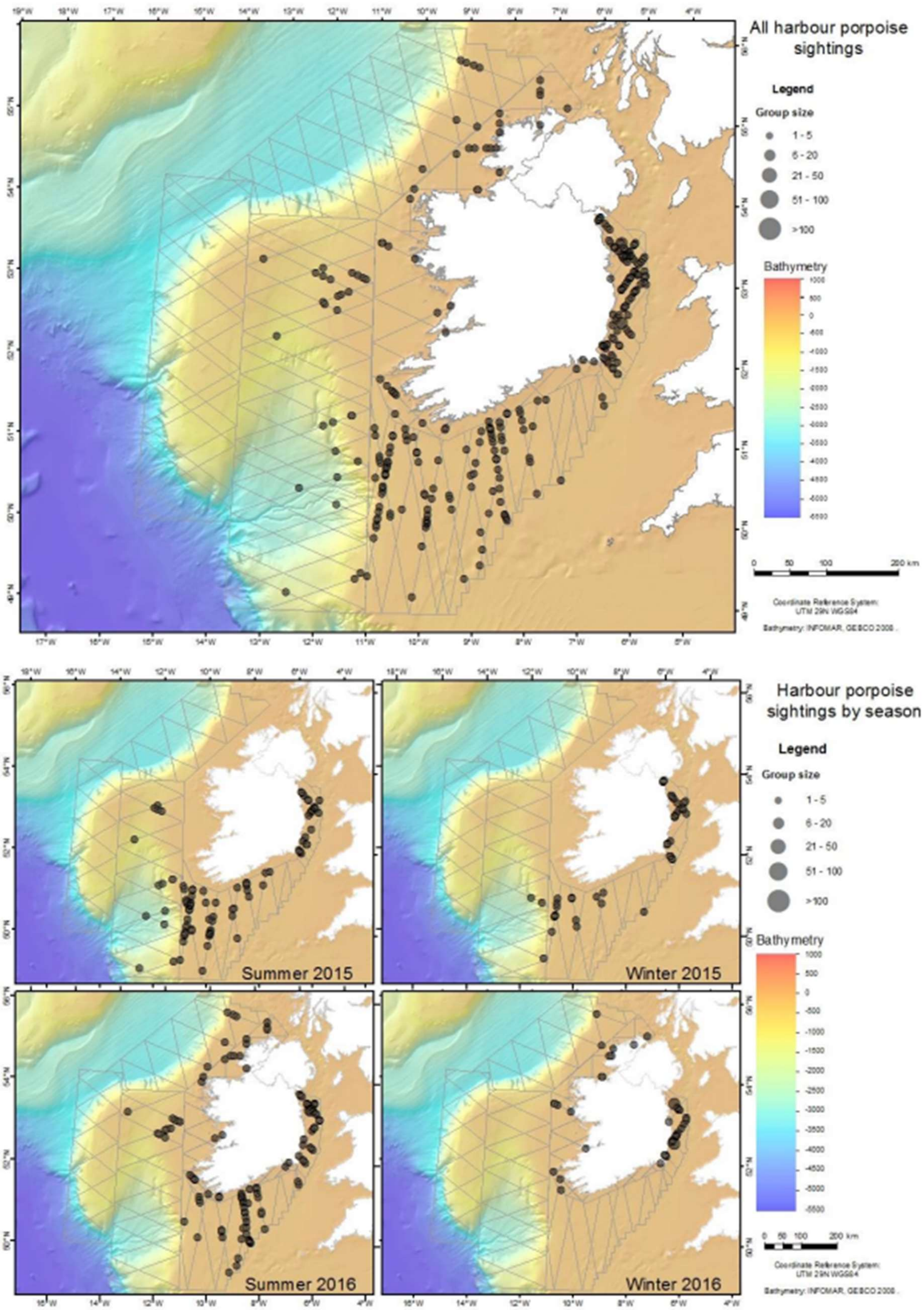


Figure 13-10: Harbour Porpoise sightings during the Phase I of the ObSERVE Aerial Surveys carried out in summer and winter 2015 and 2016 (from Rogan *et al*., 2018)

Common Bottlenose Dolphin (*Tursiops truncatus*) were sporadically observed in the Irish Sea (stratum 5) during summer 2022, with a model-based estimate of 0.059 dolphins per km^2 (Figure 13-11), showing this species' preference for continental shelf waters (Figure 13-12). No Bottlenose (*Tursiops truncatus*) or Common Dolphin (*Delphinus delphis*) were sighted in stratum 5 during Phase I of the ObSERVE Aerial Surveys (Rogan *et al.,* 2018).

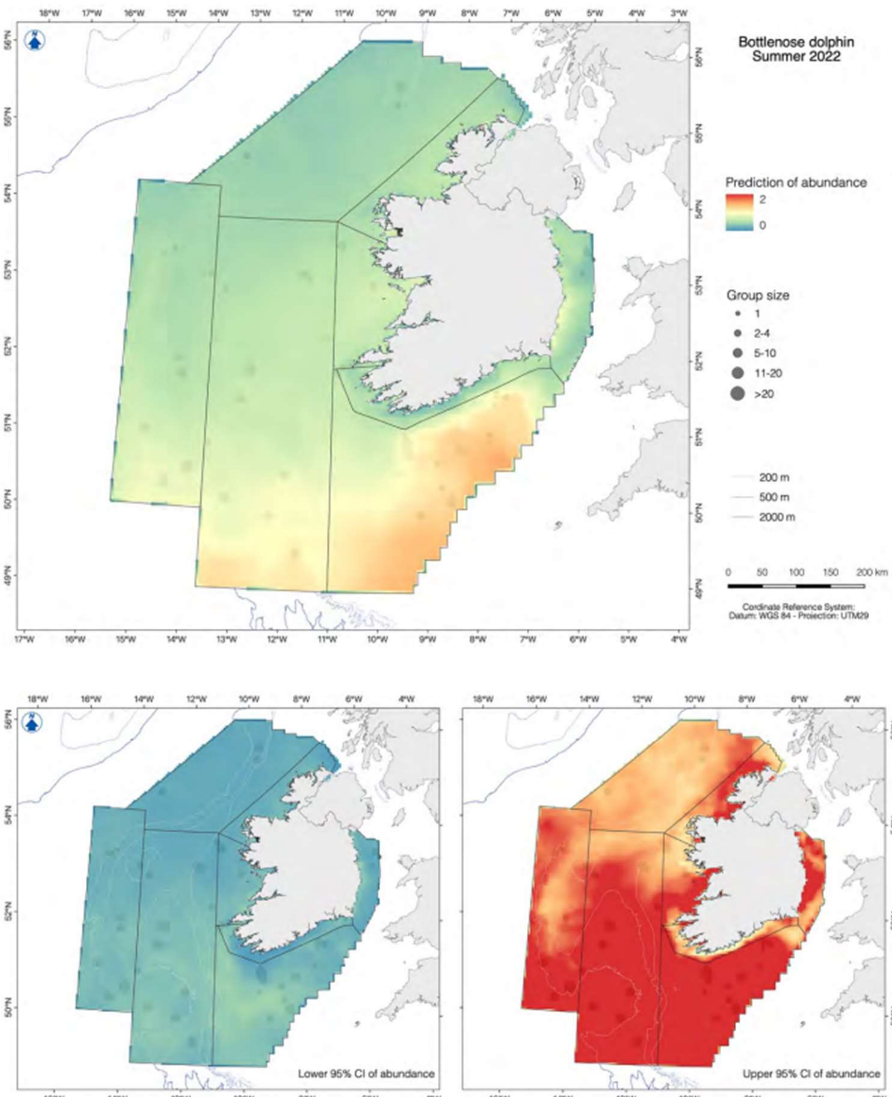


Figure 13-11: Predicted summer distribution of Bottlenose Dolphin in 2022 during Phase II of the ObSERVE Aerial Surveys (from Giralt Paradell *et al*., 2024)

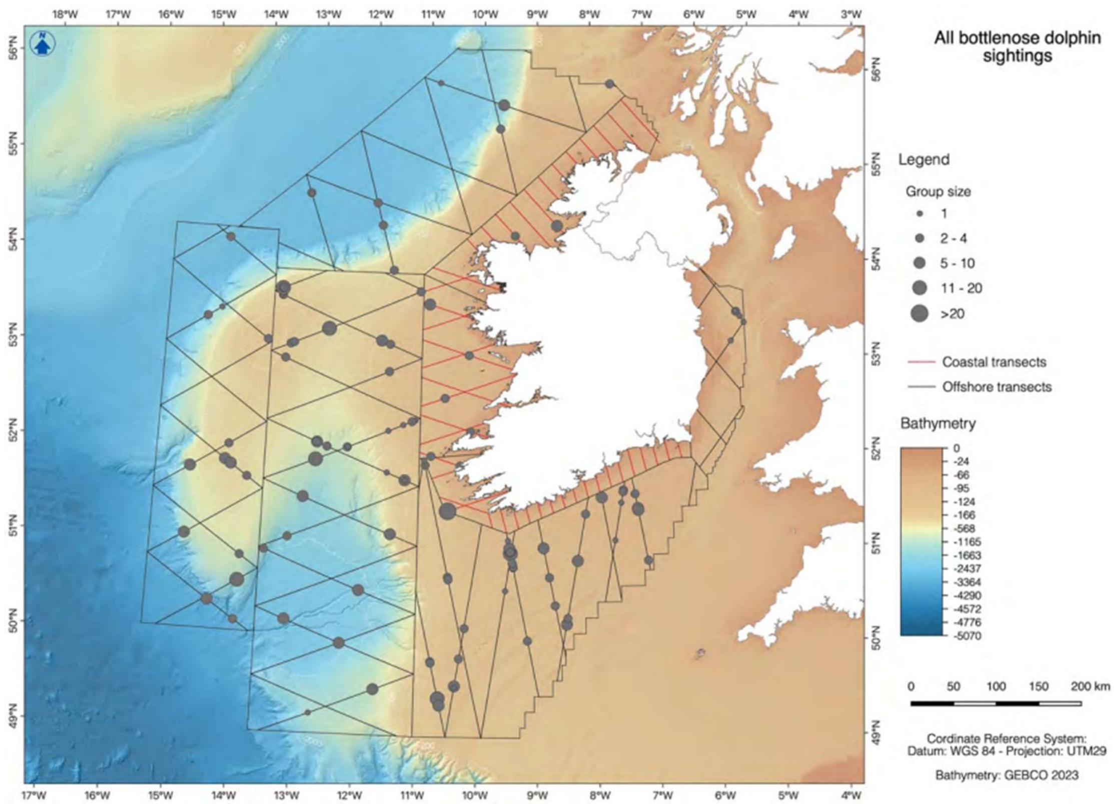


Figure 13-12: Sightings of Bottlenose Dolphin across all surveys. No surveys were carried out in winter 2021. Grey lines indicate the survey track lines in the offshore strata and red lines indicate the track lines in the coastal strata. Circles are proportional to the number of dolphins in each sighting (from Rogan *et al*., 2018).

Short-Beaked Common Dolphin (*Delphinus delphis*), although less frequent compared to other areas, were also observed off the southeast coast during summer (model-based estimate of 0.411 dolphins per km^2; Figure 13-13) and winter 2022 (model-based estimate of 0.792 dolphins per km^2; Figure 13-14). Only one sighting of a White-Beaked Dolphin (*Lagenorhynchus albirostris*) was reported during the summer 2022 with sporadic sightings of Risso's Dolphin (*Grampus griseus*) recorded during the same period; therefore, no abundance estimates were generated for these species. An unidentified dolphin was also recorded in stratum 5 during winter 2022 (Giralt Paradell *et al*., 2024).

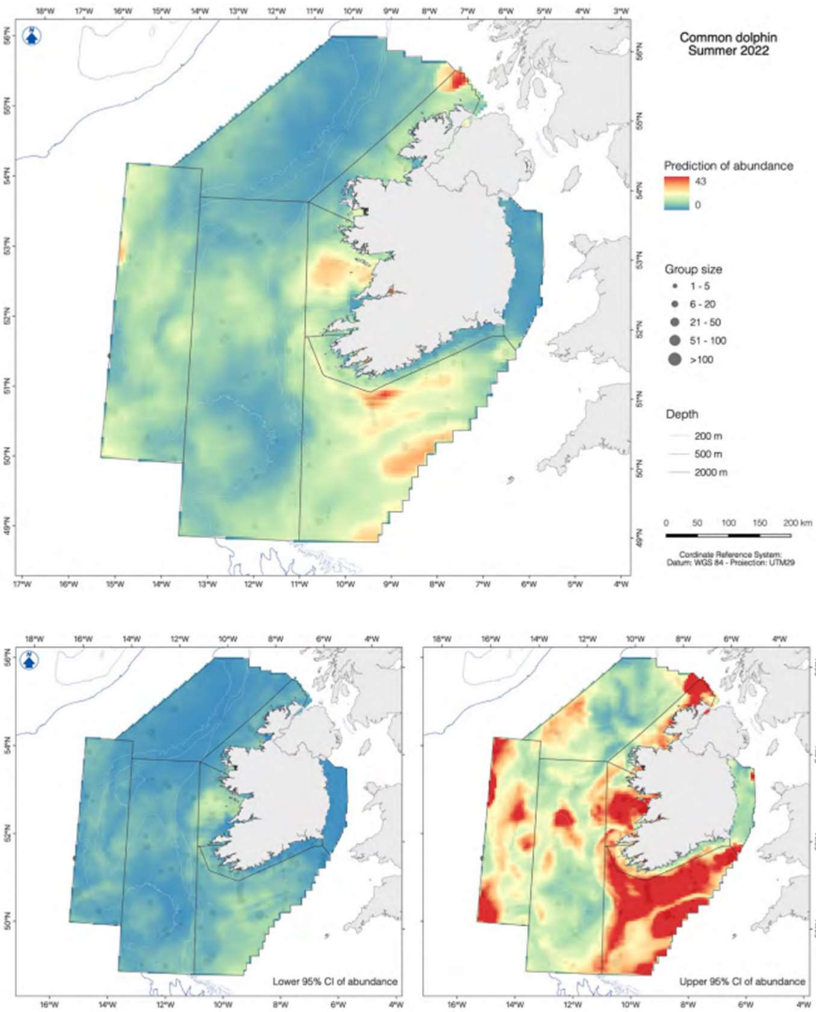


Figure 13-13: Predicted summer distribution of Common Dolphin in 2022 during Phase II of the ObSERVE Aerial Surveys (from Giralt Paradell *et al*., 2024)

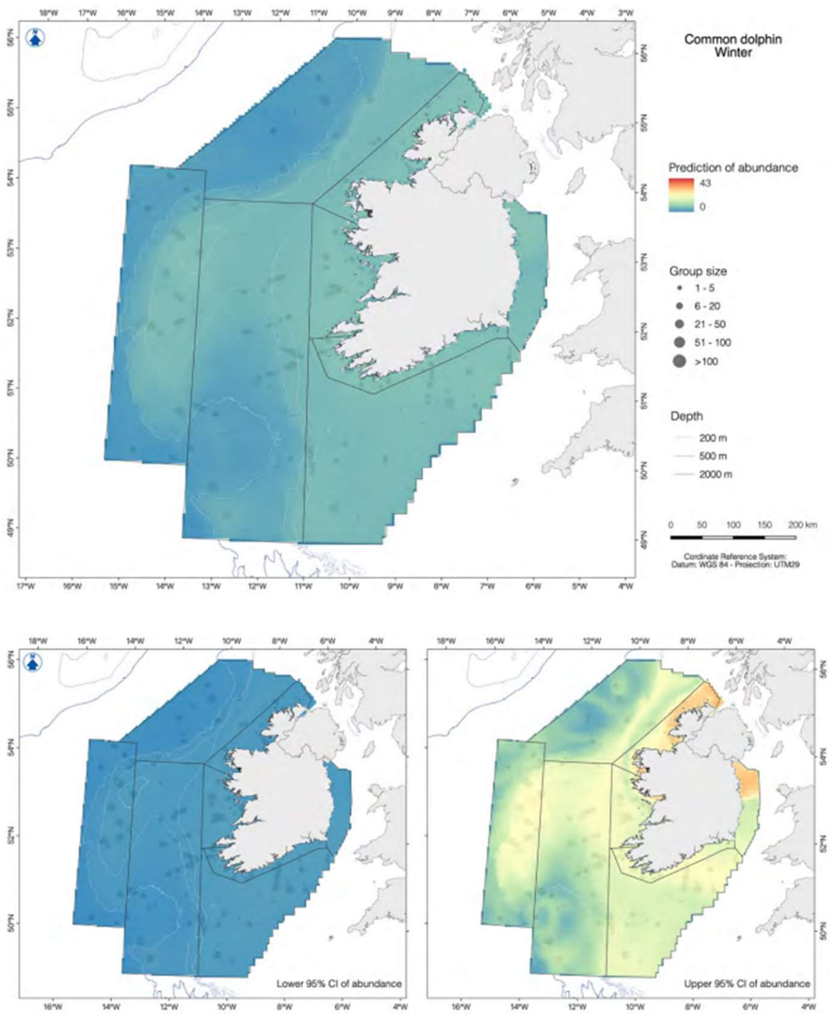


Figure 13-14: Predicted winter distribution of Common Dolphin in 2022 during Phase II of the ObSERVE Aerial Surveys (from Giralt Paradell *et al*., 2024)

Minke Whale (*Balaenoptera acutorostrata*) was the most frequently sighted baleen whale during the aerial surveys and the only sighted baleen species off the southeast of Ireland (Figure 13-15); however, this species was only observed during the summer in both years, and with very low model-based estimates of 0.014 and 0.009 animals per km^2 in 2021 and 2022, respectively (Giralt Paradell *et al*., 2024). No Minke Whale was observed in stratum 5 during Phase I of the ObSERVE Aerial Surveys (Rogan *et al.,* 2018).

Furthermore, Giralt Paradell *et al.* (2024) recorded calves of Harbour Porpoise (four), Bottlenose Dolphin (one), Common Dolphin (one) and an unidentified dolphin species (one) in the Irish Sea in both seasons.

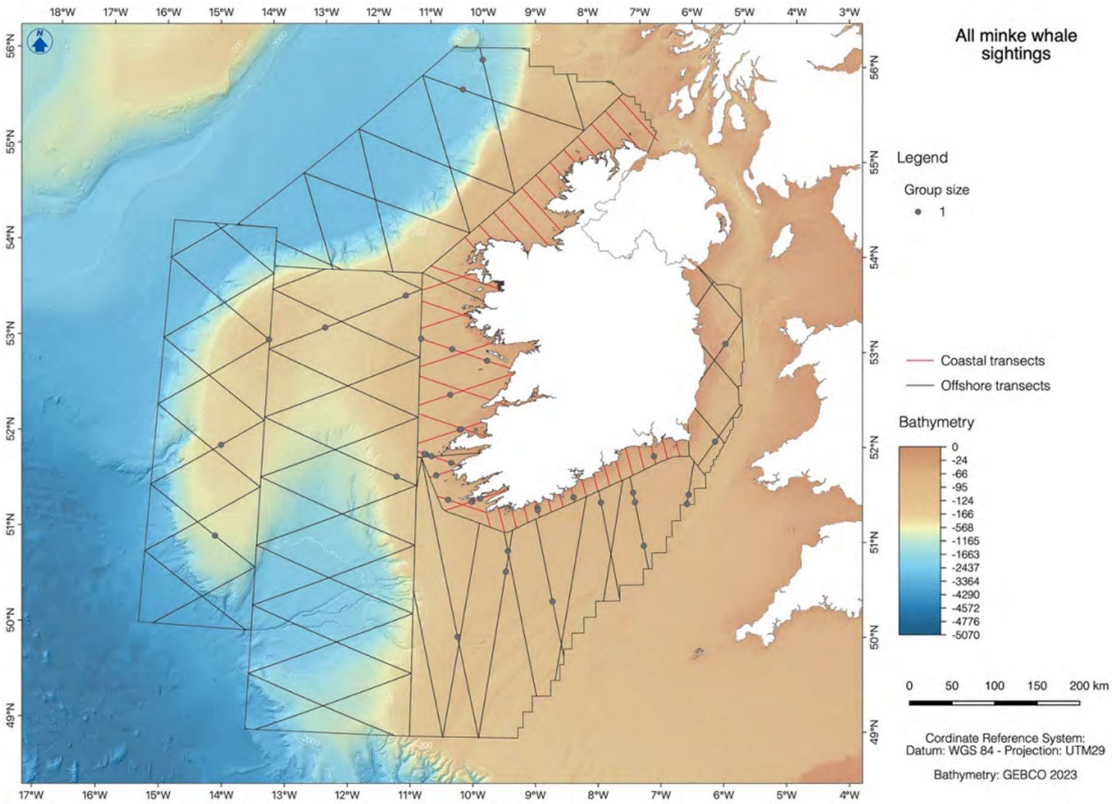


Figure 13-15: Sightings of Minke Whale across all surveys. No surveys were carried out in winter 2021. Grey lines indicate the survey track lines in the offshore strata and red lines indicate the track lines in the coastal strata. Circles are proportional to the number of dolphins in each sighting (from Giralt Paradell *et al*., 2024).

Waggitt *et al.* (2020) presented distribution maps of cetaceans throughout the UK and Ireland from a wide range of datasets resulting in 2.68 million km of collated survey effort data between 1980 and 2018. They showed a similar pattern to Rogan *et al.* (2018), with only Harbour Porpoises occurring throughout the area of interest with the occasional Risso's Dolphin.

Older data confirm this pattern. Reid *et al*. 2003 used effort-related sightings data covering the period 1973 to 1999 to produce the Atlas of Cetacean Distribution in North-West European Waters, presenting the distribution of the 28 cetacean species occurring in NW European waters. Similarly to the authors cited above, Reid *et al*. 2003 found that Harbour Porpoise was the most frequently sighted cetacean species in the study area, although occurring in the Irish Sea at lower densities than in other areas of the Atlantic seabord, such as off south-west Ireland and south-west Wales. Minke Whale, Bottlenose Dolphin, Common Dolphin and Risso's Dolphin have all been occasionally sighted in the vicinity of the study area between 1973 and 1999, while the Killer Whale (*Orcinus orca*) was considered to be rare in the Irish and Celtic Seas in the same period (Reid *et al*. 2003).

Paxton *et al.* (2016) used effort-linked sightings data contained within the Joint Cetacean Protocol (JCP) data resource to produce a set of maps that provide an indicative illustration of the average distribution and abundance of the most common cetacean species occurring in NW European waters between 1994 and 2010. A number of caveats and limitations were pinpointed within the report, namely that JCP Phase III data are not suitable for detecting all but dramatic changes in population size, that inferences made from the JCP analyses are unlikely to be reliable at scales of less than approximately 1000 km^2, and that derived density/abundance estimates can only be used in impact assessments when scaled to the total abundance of reference populations.

JNCC carried out this work in 2017 scaling JCP Phase III density surfaces to SCANS III abundance estimates for the different Management Units and made scaled density maps for the period 2007-2010 available together with the Paxton *et al.* (2016) report. These maps confirm that Harbour Porpoise was the most abundant cetacean in the vicinity of the Marine Mammal Study Area in this period with a scaled density of 0.011-0.02 animals/km^2 followed by Bottlenose Dolphin with a scaled density of 0.0051-0.01 animals/km^2. The remaining species modelled – Minke Whale, Risso's Dolphin, Common Dolphin, White-beaked Dolphin (*Lagenorhynchus albirostris*) and White-sided Dolphin (*Lagenorhynchus acutus*) – were virtually absent from the study area between 2007-2010, with scaled densities of 0.0-0.002 animals/km^2.

The only dedicated small-scale cetacean survey in the vicinity of the Proposed Development Boundary was carried out by Berrow *et al.* (2008) as part of an investigation funded by the National Parks and Wildlife Service (NPWS) to identify potential Special Areas of Conservation (SAC) for Harbour Porpoise. Three surveys were carried out between July and September 2008 with Harbour Porpoise distributed throughout the study area but with higher concentrations to the southeast of the site (Figure 13-16). Density estimates of 0.58 Harbour Porpoise per km^2 resulted in an abundance estimate of 87±36.3 (95% CI: 39-196). Berrow *et al.* (2008, 2014) showed that Harbour Porpoise density was low compared to sites elsewhere and not considered appropriate for SAC designation.

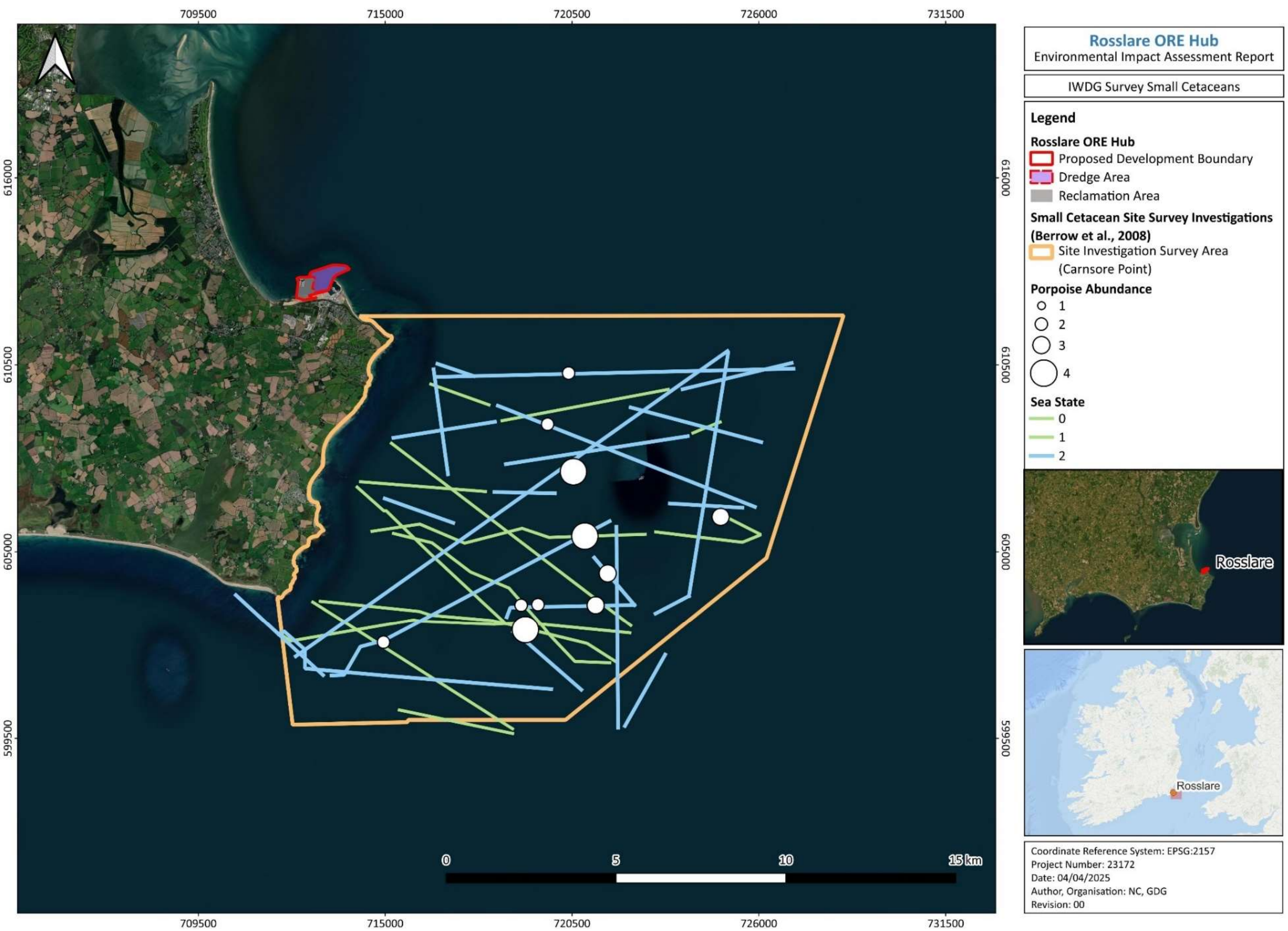


Figure 13-16: Dedicated Harbour Porpoise transects and sightings off Carnsore Point, July to September 2008 (adapted from Berrow *et al.,* 2008)

Berrow *et al.* (2011) carried out nearshore surveys in the Irish sea on behalf of the NPWS (Figure 13-17). Harbour Porpoise was the most abundant species recorded. Although sufficient sightings for a robust density estimate were not available for Harbour Porpoise in Block B (southern Irish Sea, Figure 13-17a), the available data suggested that densities were lower in the southern Irish Sea compared to areas further north. In Block B the sightings rate was calculated at 0.101 sightings per km or 1.91 sightings per hour of survey effort, and sightings rate of Harbour Porpoise was estimated at 0.159 porpoise per km or 3.0 porpoises per hour of survey. This was an order of magnitude greater than the relative abundance of Grey and Harbour Seal in the same block.

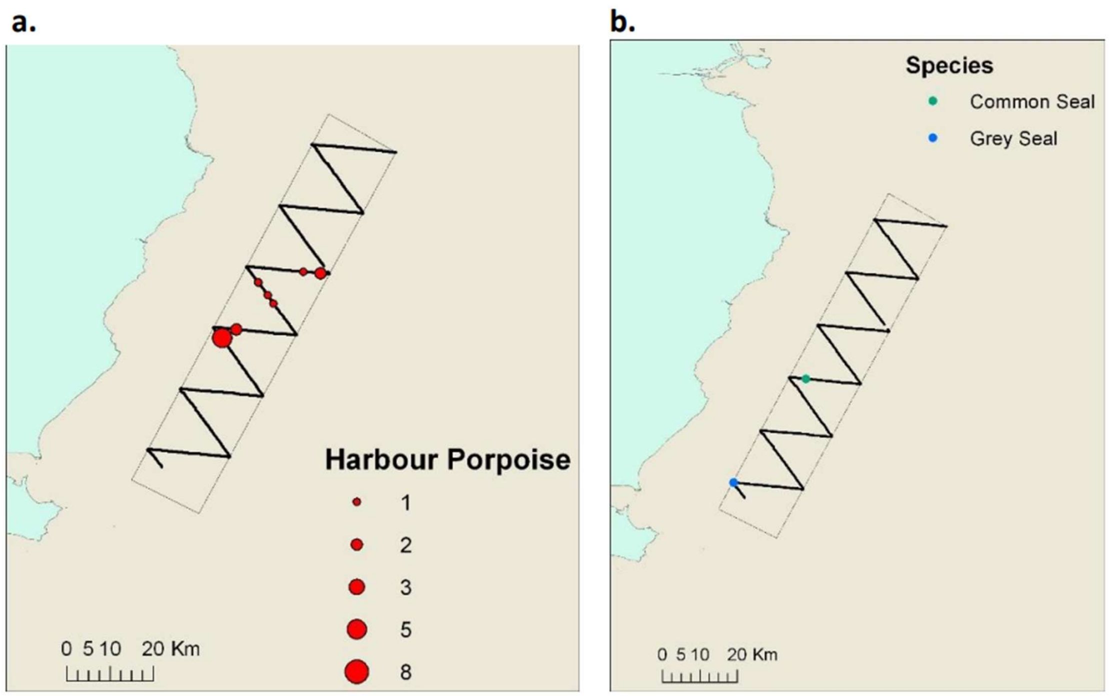


Figure 13-17: Relative abundance of a. Harbour Porpoise and b. Grey and Common or Harbour Seals in the southern Irish Sea (Block B) on the 2nd August 2011 (from Berrow *et al*., 2011)

A thorough marine mammal assessment was carried out by Berrow (2022) as part of an Annex IV Assessment of the potential impacts of the development of Berth 3 at Rosslare Europort. A review of validated cetacean records submitted to the IWDG from the public resulted in 186 records which consisted of six cetacean species and two additional species, the Leatherback Turtle (*Dermochelys coriacea)* and the Basking Shark (*Cetorhinus maximus*). Risso's Dolphin and Harbour Porpoise were the most frequently recorded cetacean species accounting for 53% of all cetacean records. Common and Bottlenose Dolphin were also frequently recorded and two baleen whale species, Minke and Humpback (*Megaptera novaeangliae*) whale, were occasionally recorded.

Very few records of strandings have been recorded in the area, with no species recorded as having stranded that are not considered in this desk study (IWDG, *pers comm*).

All species of cetaceans recorded in Ireland have been assessed as having a favourable conservation status, with the exception of Humpback Whale, Killer Whale (*Orcinus orca*), Blue Whale (*Balaenoptera musculus*), Northern Bottlenose Whale (*Hyperoodon ampullatus*) and Sei Whale

(*Balaenoptera borealis*), for which the overall status remains unknown due to limited ongoing information on the species' occurrence and population ecology in Irish waters (NPWS, 2019a).

13.3.1.3 PINNIPEDS

Grey and Harbour Seal are distributed around the entire Irish coast with Grey Seal being generally more abundant along the western seaboard and off the southwest coast (Cronin *et al.,* 2004; Ó Cadhla *et al*., 2007; Ó Cadhla & Strong, 2008). The conservation status of Grey and Harbour Seal in Ireland has been assessed as favourable (NPWS, 2019a), although excessive disturbance at key breeding and haul-out sites can have a significant negative impact.

Grey Seal studied on the Blasket Islands, Co Kerry fed predominantly on gadiformes and salmonids (Gosch *et al*., 2014) while animals from the Western Irish Sea also included flatfish in their diets (Kiely *et al.,* 2000). The diet of Harbour Seal includes sandeel, sole and *Trisopterus* species (Kavanagh *et al.,* 2010). Tracking studies have shown journeys of hundreds of kilometres by Grey Seal (Cronin *et al*., 2011) while Harbour Seal stay much closer to their haul outs (Cronin *et al*., 2008). A study by Huon *et al.* (2021) found that while capable of extended journeys, a seal's choice of haul-out is strongly influenced by local spatial ecology. Newly available data on Grey and Harbour seal movements was used by Carter *et al.* (2022) to model habitat preference and generate at-sea distribution estimates for the entire UK and Ireland populations of both Grey and Harbour seals, finding regional differences in environmental drivers of distribution for both species which likely relate to regional variation in diet and population trends. Carter *et al.* (2022) also provided SAC-specific estimates of at-sea distribution for use in marine spatial planning, demonstrating that hotspots of at-sea density in UK and Ireland-wide maps cannot always be apportioned to the nearest SAC.

During Phase II of the ObSERVE Aerial Surveys (Giralt Paradell *et al.*, 2024), Harbour and Grey Seal could not be differentiated from the aircraft and were grouped together. Pinnipeds were seen in all seasons. Sightings occurred primarily in the coastal strata, with a smaller number recorded further offshore and one individual in the deep water of the Rockall trough. Density was high in the Irish sea, with highest concentration of sightings off the northwest coast (Figure 13-18). Generally, Harbour Seal have a more restricted nearshore coastal distribution, while Grey Seal have been tracked foraging out as far as the continental shelf edge, so the majority of these sightings are likely to be of Grey Seal. No abundance estimate was generated for pinniped species based on sightings.

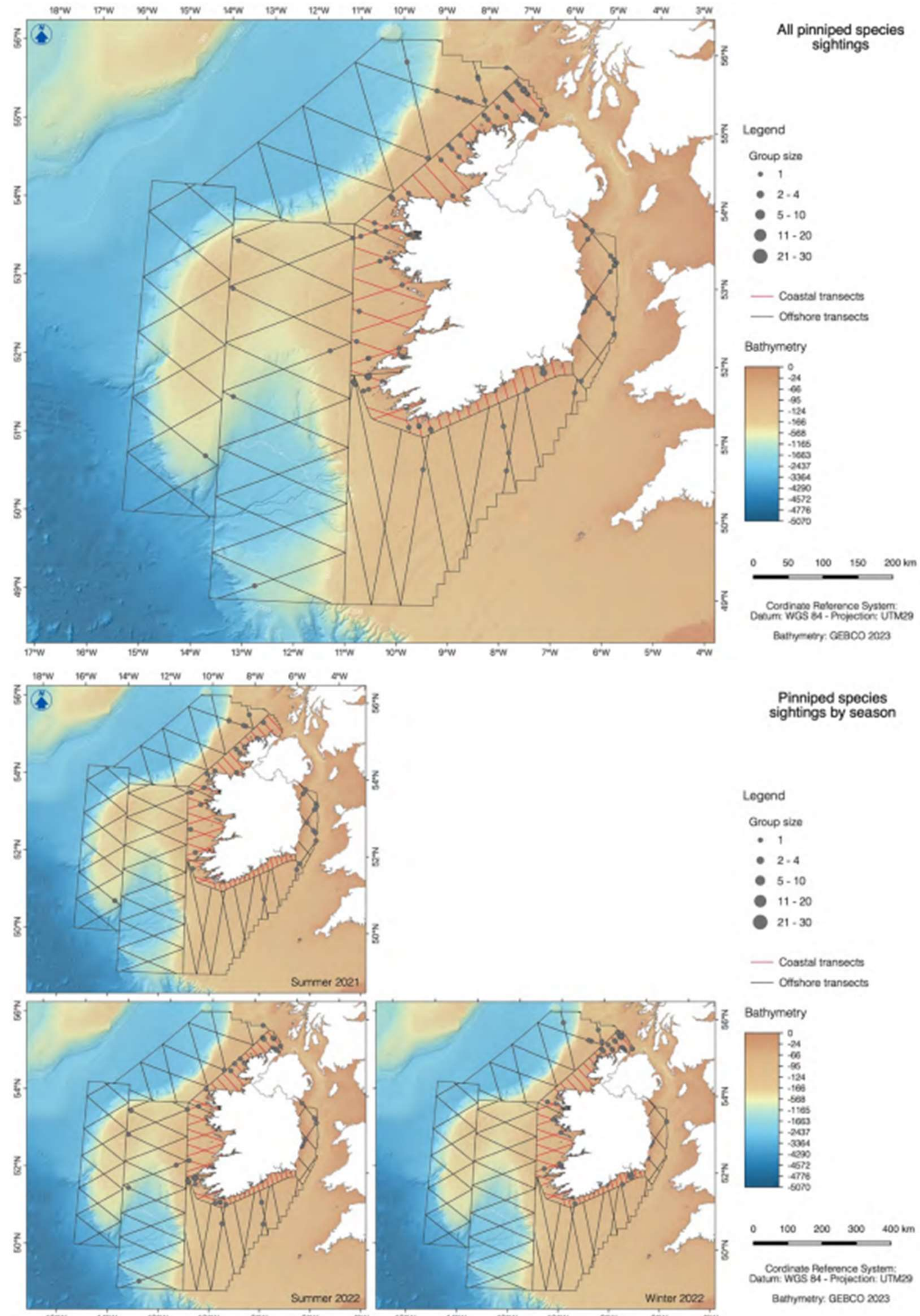


Figure 13-18: Sightings of pinniped species across all surveys (top) and in each survey period (bottom). Note that no surveys were carried out in winter 2021. Grey lines indicate the survey track lines in the offshore strata and red indicate the track lines in the coastal strata. Circles are proportional to the number of pinnipeds in each sighting (from Giralt Paradell *et al.*, 2024).

13.3.1.3.EQ. (.6)HARBOUR SEAL (*PHOCA VITULINA*)

The mouth of Wexford Harbour is around 6.8km north from Rosslare Europort. Lockley (1966) reported an average of 10 Harbour Seal in Wexford Harbour between 1964 and 1965. Harbour Seal were reported in Wexford Harbour during NPWS surveys during 2003. Cronin *et al.* (2004) reported 17 Harbour Seal hauled out at two sites in Wexford Harbour on 19th August 2003 during an aerial survey (Figure 13-19).

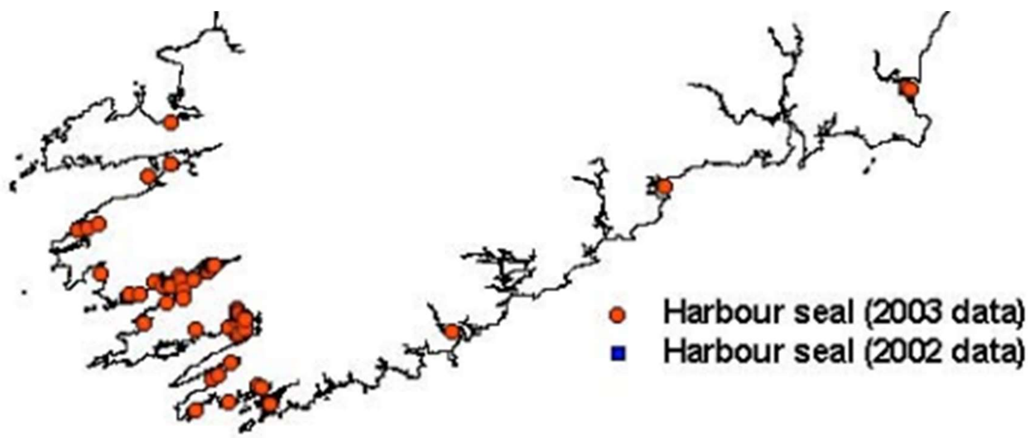


Figure 13-19: Map of the locations of groups of Harbour Seal recorded on the south coast of Ireland, August 2003 (from Cronin *et al.,* 2004)

Furthermore, an aerial survey of seals for Ireland was carried out in 2011/12 and 2017/2018 on behalf of the NPWS (Figure 13-20). The total number of Harbour Seal for Ireland in 2017/2018 was 4,007, which was 14.8% higher than a similar survey carried out in 2011/2012 (3,489), which is equivalent to an average annual increase of 2.3% over six years (Morris & Duck, 2019). The overall difference in these national Harbour Seal counts was due to slightly higher numbers found in all three main Harbour Seal regions (South-west, West and North combined: +496, equivalent to a 2.3% average annual increase). Off the southeast coast, Harbour Seal counts declined in Wexford Harbour from 49 to 33 during this period.

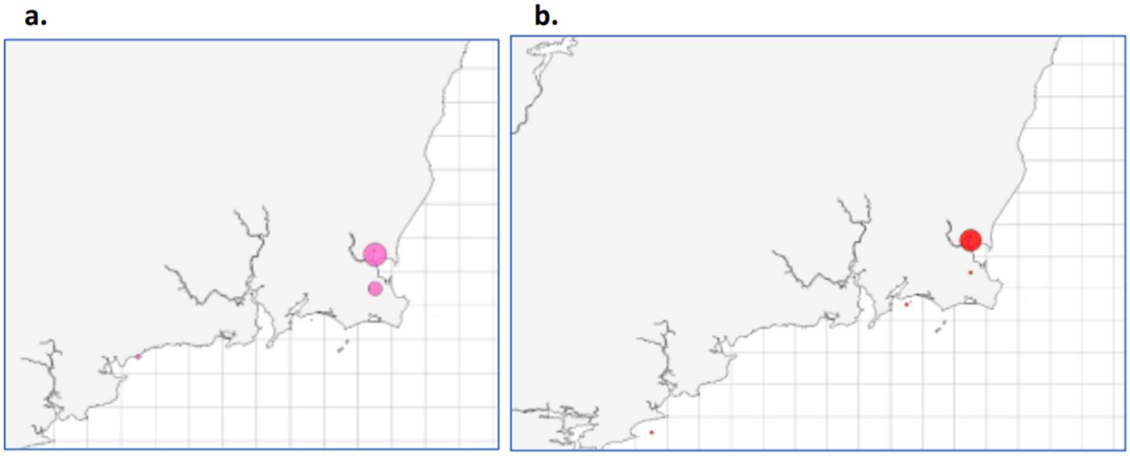


Figure 13-20: Distribution of Harbour Seal of the southeast coast from aerial surveys carried out in a. 2011/12 and b. 2017/2018 (from Morris & Duck, 2019)

Harbour seals are known to forage closer to their haul-out sites during the breeding season. Cronin *et al.* (2010) used satellite telemetry to track harbour seals from various sites in southwest Ireland, including locations in County Wexford. Their findings indicated that during the breeding season, harbour seals in Wexford foraged primarily within 20 to 50 km of their haul-out sites, such as in Wexford Harbour and around the Saltee Islands, though some individuals were recorded traveling up to 100 km when food was scarce. These seals focused their foraging efforts in shallow coastal waters and estuaries.

13.3.1.3.EQ. (.7)GREY SEAL (HALICHOERUS GRYPUS)

Grey Seal are regularly reported hauled out on sandbanks in the mouth of Wexford Harbour and on the Raven sandbar to the north of Rosslare Europort. Kiely *et al.* (2000) carried out 14 surveys of the Raven Point between June 1997 and December 1998 and counted a mean of 75 Grey Seal hauled out. Numbers peaked in the summer but were consistently high during the breeding season and female moult period.

Cronin *et al.* (2004) reported 25 Grey Seal hauled out on 19th August 2003 during an aerial survey for Harbour Seal. A further 30 Grey Seal were reported at Carnsore Point and 17 on Tuskar Rock on the same day. Ó Cadhla *et al.* (2007) reported 130 hauled out on the Raven spit and banks on 6th March 2007 during an aerial survey during the moulting period, which are numbers of national significance (Figure 13-21). A single Grey Seal pup was reported during an aerial survey of Grey Seal breeding sites in 2005, suggesting the site is more important for moulting and resting than for breeding.

The nearest protected site for Grey Seal is Great Saltee Island SAC (Site Code 000707) off the south Wexford coast over 21 km by sea from Wexford Harbour. Grey Seal may forage over long distances even during breeding season and with dependent young and may occasionally swim upriver when foraging. Kiely *et al.* (2000) reported individual Grey Seal moving between colonies off the southwest of Wales and the Raven Point, Wexford, suggesting some of the seals recorded during the high counts in the moulting period could originate from colonies outside Ireland. Carter *et al.* (2022) demonstrated a disconnect between monitored sites where impacts are likely to be detected (i.e., SACs) and areas where impacts are likely to occur (i.e., at sea). They have shown that, for Grey Seals, SACs designated based on breeding numbers cannot be reliably linked to areas where individuals may be exposed to threats at sea due to local redistribution outside of the breeding season and partial migration.

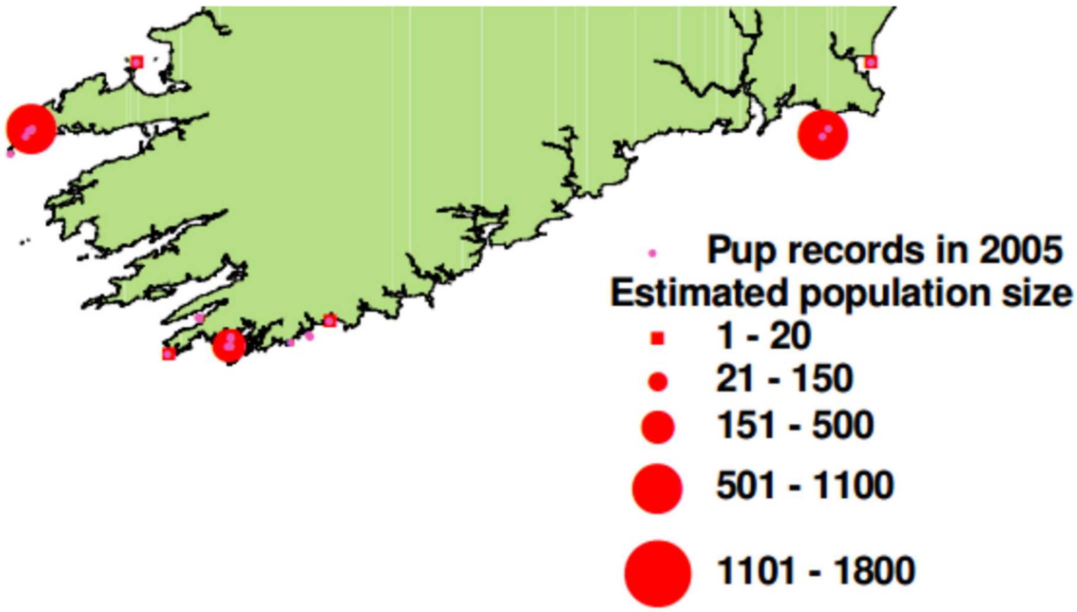


Figure 13-21: Map of the locations of Grey Seal pupping locations recorded on the south coast of Ireland in 2005 (from Ó Cadhla *et al.,* 2007)

The total number of Grey Seal counted in 2017/2018 (3,698) by Morris and Duck (2019) was the highest recorded in summer so far and 25% higher than a similar aerial survey carried out in 2011/2012 (2,964). This is equivalent to an average annual increase of 3.8% over six years. Off the southeast coast, Grey Seal counts increased from 239 to 550 individuals during this period (Figure 13-22; Morris & Duck, 2019).

Grey Seal are known to forage over large areas. Cronin *et al*. (2016) attached Fastloc/GSM tags (SMRU Ltd, UK) on Grey Seal from haul out sites on the Raven Point, Wexford Harbour, Co. Wexford. They showed foraging ranges from Co. Wexford as far north as the Isle of Man in the Irish Sea and as far south as the southwest coast of Wales (Figure 13-23).

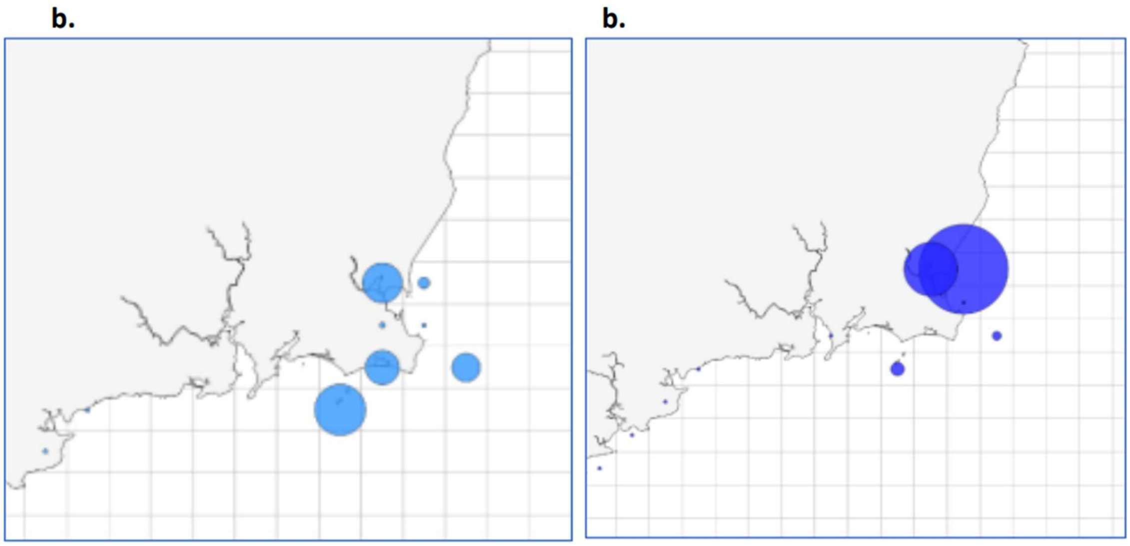


Figure 13-22: Distribution of Grey Seals of the southeast coast from aerial surveys carried out in a. 2011/12 and b. 2017/2018 (from Morris & Duck, 2019)

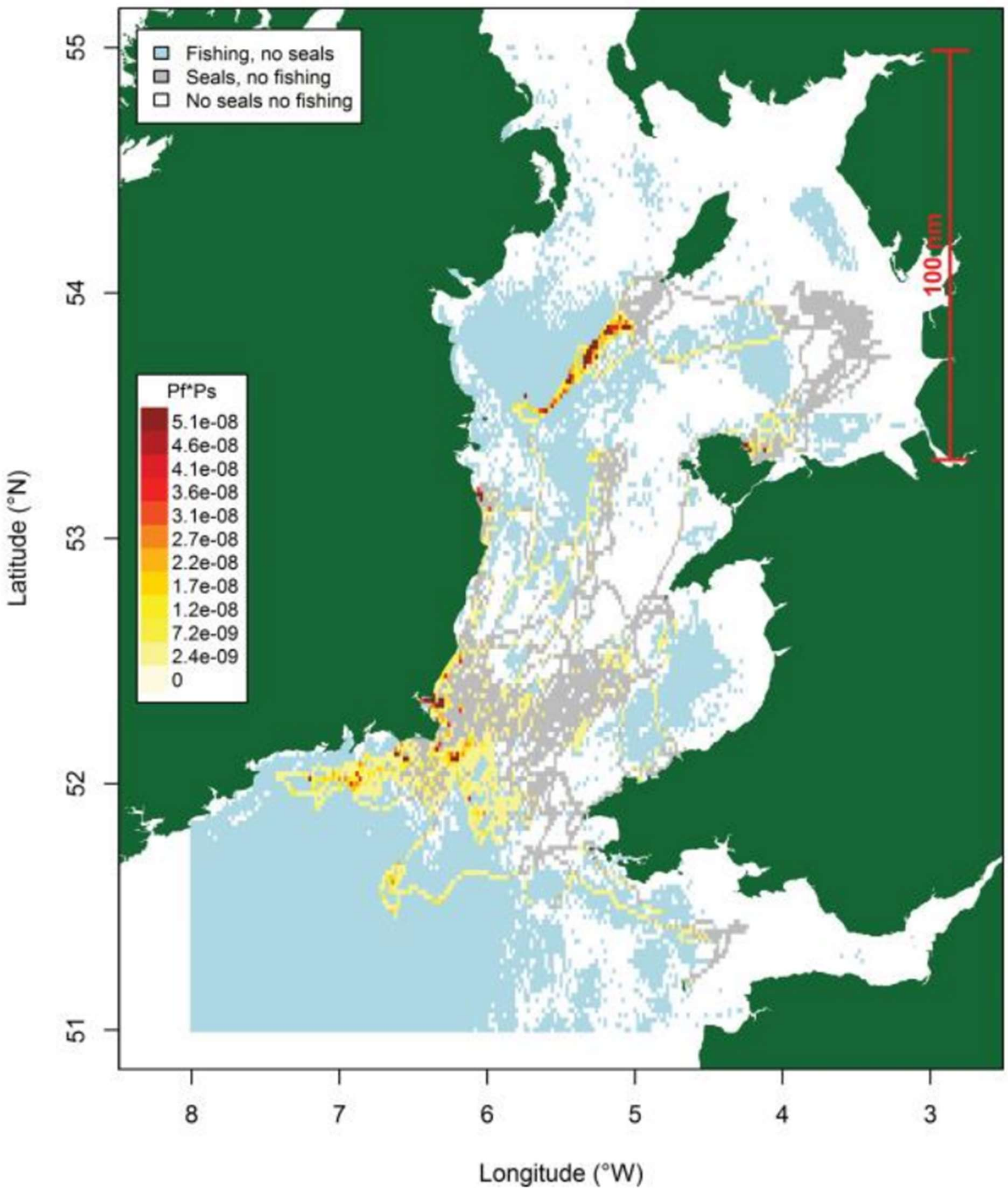


Figure 13-23: Distribution of effort of tagged Grey Seal, fishing vessels and areas of overlap (yellow to red) during 2013 and 2014 (from Cronin *et al.*, 2016)

13.3.1.4 DESIGNATED NATURE CONSERVATION SITES

13.3.1.4.EQ. (.8)SLANEY RIVER VALLEY SAC

The Slaney River Valley SAC (Site Code 000781) has regionally significant numbers of Harbour Seal and lies 6.6 km (by sea) north from the Proposed Development. The SAC is an important breeding, moulting and resting haul-out for Harbour Seal (NPWS, 2015). Harbour Seal occurs year-round in Wexford Harbour where several sandbanks are used for breeding, moulting and resting activity

(NPWS, 2011). NPWS report in their site synopsis that at least 27 individuals regularly occur within the site (Lockley, 1966; Cronin *et al*., 2004; and unpublished National Parks and Wildlife Service records).

The Conservation Objectives for Harbour Seal in the Slaney River Valley SAC are:

- Species range within the site should not be restricted by artificial barriers to site use
- The breeding sites should be maintained in a natural condition
- The moult haul-out sites should be maintained in a natural condition
- The resting haul-out sites should be maintained in a natural condition
- Human activities should occur at levels that do not adversely affect the Harbour Seal population at the site

NPWS (2011) haul out sites for Harbour Seals are shown in Figure 13-24.

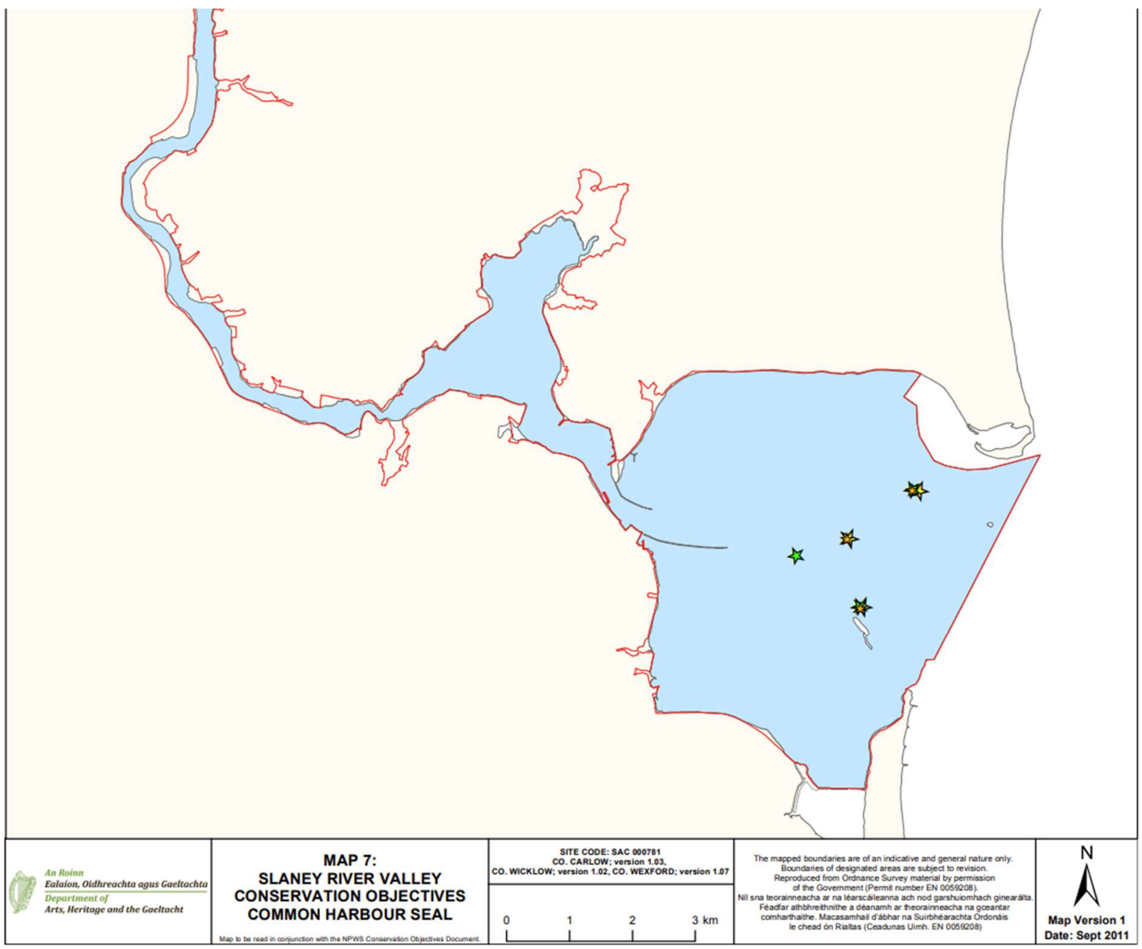


Figure 13-24: Harbour Seal haul out sites (from NPWS, 2011)

13.3.1.4.EQ. (.9)SALTEE ISLANDS SAC

An important breeding, pupping and haul out site for Grey Seal occurs on Great Saltee (Ó Cadhla *et al.*, 2007), which is less than 22 km over water from the Proposed Development and is designated as an SAC (Site Code 000707; Figure 13-25) with Grey Seal as a Qualifying Interest (QI). An estimated 158 Grey Seal were hauled out on Great Saltee on 21st September 2005 (Ó Cadhla *et al.,* 2007) and 246 seals on 6th March 2007 (Ó Cadhla & Strong, 2007).

The Conservation Objectives for Grey Seal in the Saltee Islands SAC are:

- Species range within the site should not be restricted by artificial barriers to site use
- The breeding sites should be maintained in a natural condition
- The moult haul-out sites should be maintained in a natural condition
- The resting haul-out sites should be maintained in a natural condition
- The Grey Seal population occurring within this site should contain adult, juvenile and pup cohorts annually
- Human activities should occur at levels that do not adversely affect the Grey Seal population

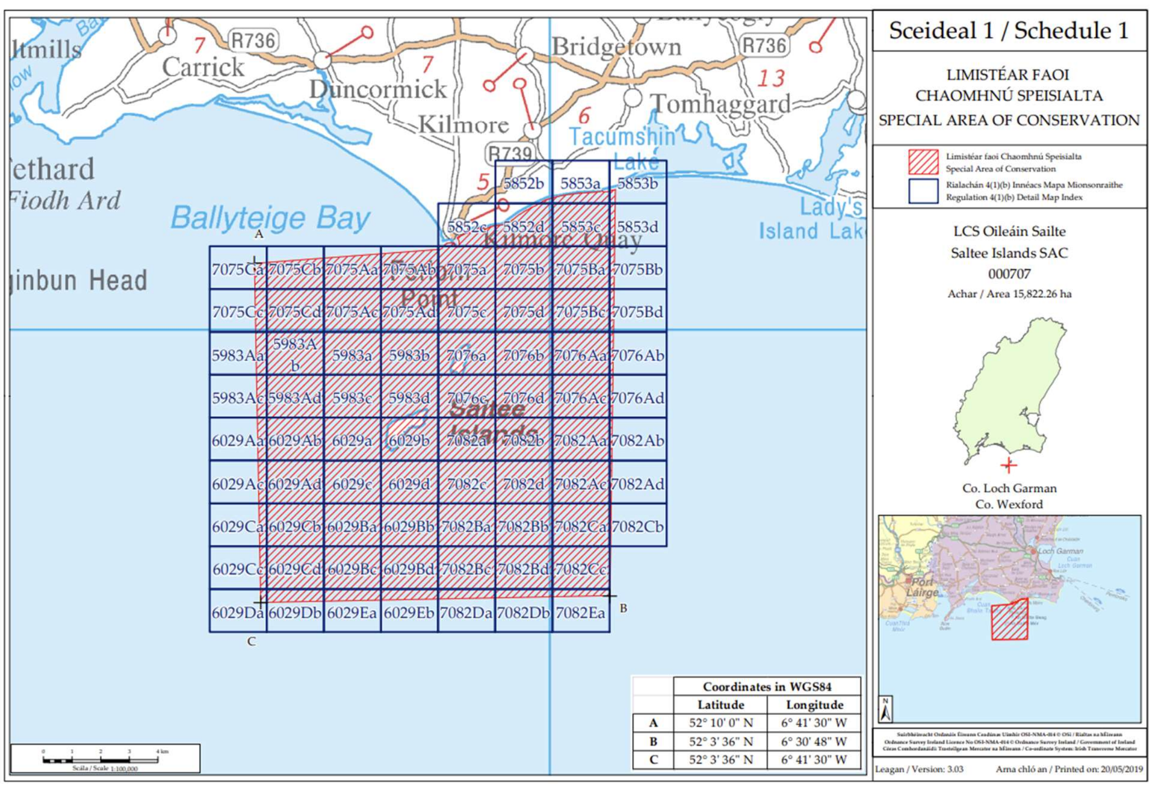


Figure 13-25: Saltee Islands SAC delimitation (NPWS, 2019b)

13.3.1.4.EQ. (.10)BLACKWATER BANK SAC

In March 2024, the Minister for Housing, Local Government and Heritage added Harbour Porpoise as a QI to Blackwater Bank SAC (Site Code 002953) in County Wexford (Figure 13-26). The inclusion of this species as a QI has resulted in additional Activities Requiring Consent (ARC) being applied to the site (NPWS, 2024a).

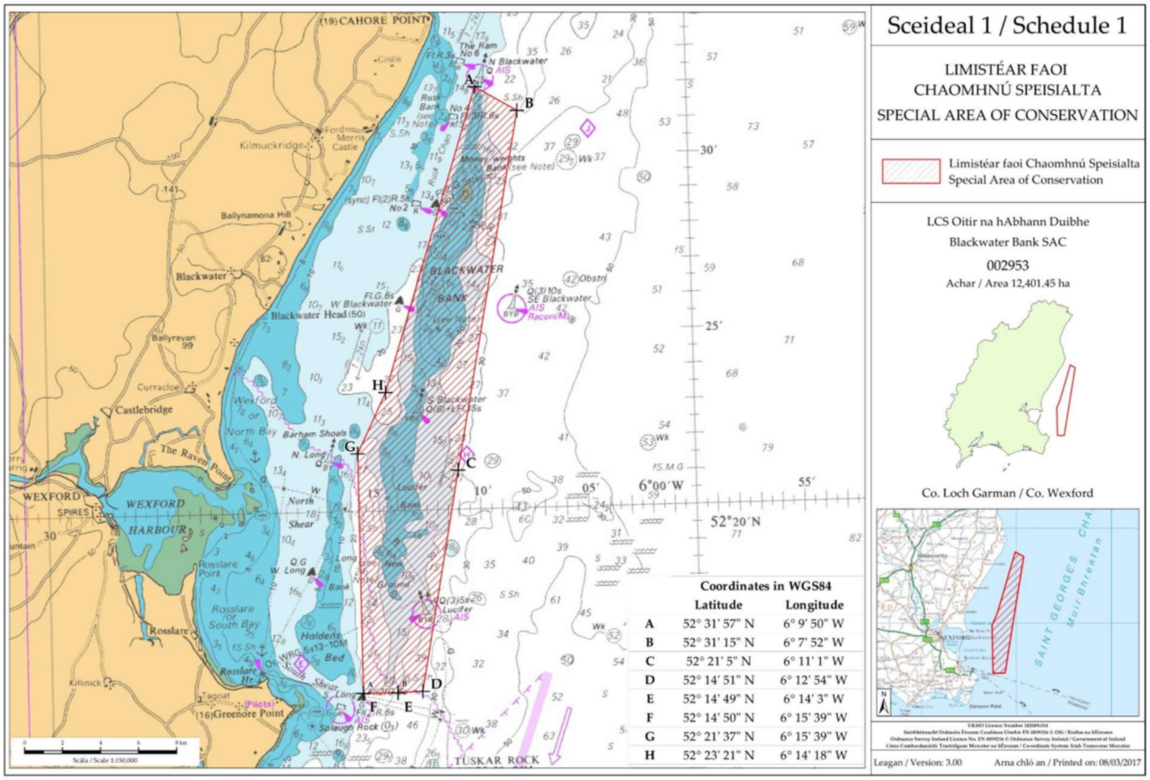


Figure 13-26: Blackwater Bank SAC delimitation (NPWS, 2017)

13.3.1.5 CARNSORE POINT SAC

As for the Blackwater Bank SAC, the Minister also added Harbour Porpoise as a QI to Carnsore Point SAC (Site Code 002269) in County Wexford (Figure 13-27). The addition of Harbour Porpoise as a QI has resulted in an additional ARC being added to the list of ARCs that apply to this site (NPWS, 2024b).

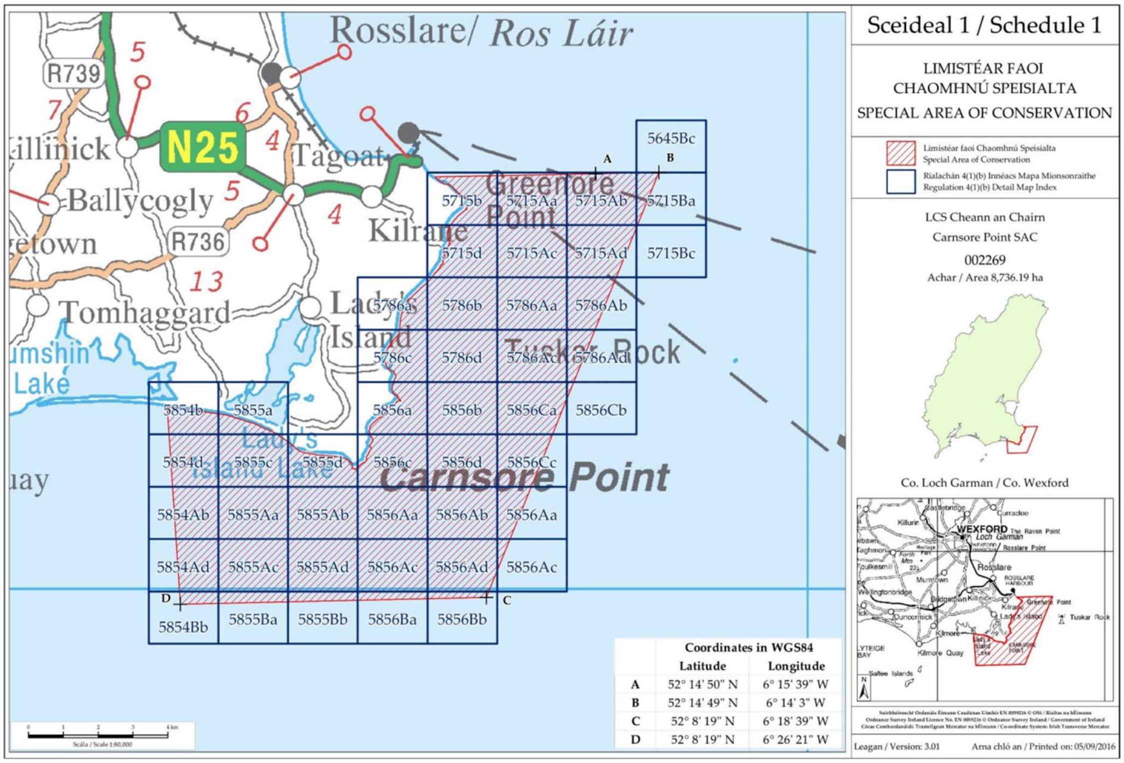


Figure 13-27: Carnsore Point SAC delimitation (NPWS, 2016)

13.3.1.6 STATIC ACOUSTIC MONITORING

13.3.1.6.EQ. (.11)CETACEANS

The main species of interest in the area include Harbour Porpoise, Bottlenose Dolphin (*Tursiops truncatus*) and Grey (*Halichoerus grypus*) and Harbour Seal (*Phoca vitulina*). The Slaney River Valley SAC (Site Code 000781) holds regionally significant numbers of harbour seal within 10km of the Proposed Development. Harbour Seal occur year-round in Wexford Harbour where several sandbanks are used for breeding, moulting and resting activity (NPWS 2011). More recently, the Blackwater Bank SAC (Site Code 02953) and Carnsore Point SAC (Site Code 02269) have had Harbour Porpoise added to their list of Qualifying Interests. The western boundary of the Blackwater Bank SAC lies around 4.9 km from Rosslare Harbour, while the northern boundary of Carnsore Point SAC lies around 1.4 km to the south.

For the Proposed Development, underwater noise impacts are possible from construction activities including piling and blasting while the long-term operation of the Proposed Development, especially if vessel traffic is to increase significantly, may also contribute to increased levels of underwater noise.

13.3.1.6.EQ. (.12)SEALS

As a non-invasive approach, passive acoustic monitoring facilitates the study of seal populations in their natural habitats, minimising human disturbance. By analysing seal vocalisations, we can obtain valuable insights into their behaviour, communication patterns, and population dynamics.

Grey Seal (*Halichoerus grypus*) are known for their distinctive vocal behaviours, particularly during breeding and social interactions. These seals exhibit strong site fidelity, often returning to specific, remote haul-out sites on rocky coasts or offshore islands to rest, moult, and breed, providing them shelter from human disturbances and predators (Bonner, 1972; Kiely *et al*., 2000; Gerondeau *et al*., 2007). Although they share some similarities with Harbour Seal (*Phoca vitulina*), Grey Seal are notably more vocal underwater, especially in the context of their seasonal activities (Asselin *et al*., 1993; Dunn *et al.,* 2014; McCulloch, 2000).

Underwater vocalisations play a crucial role in mother-pup recognition, with pups producing individually distinctive calls to attract their mothers, who often leave them alone for extended periods (Davies, 1949; Fogden, 1971; Caudron *et al*., 1998; McCulloch & Boness, 2000; Smiseth & Lorentsen, 2001). Additionally, during the mating season, male Grey Seals use vocalisations and physical displays to assert dominance and attract females, often employing short, broadband calls (Miksis-Olds *et al*., 2016), typically less than 3 kHz, with clicks with harmonics reaching 15–30 kHz (Asselin *et al*., 1993; Oliver, 1978; Schevill *et al*., 1963;Table 13-2) and, more recently observed, forelimb claps as underwater signals (Hocking *et al*., 2020). This diverse vocal repertoire underlines the importance of acoustic communication within the species, offering insight into their social structures and competitive behaviours.

Table 13-2: Grey Seal underwater vocalisations (general classification) adapted from Reynolds and Rommel (1999)

Signal type	Frequency range (kHz)	Frequency Near Maximum Energy (kHz)	References
Clicks, hiss	0-30, 0-40	-	Oliver, 1978; Schevill *et al*., 1963
6 calls, 9 calls, 10 call types	0.1-5, 0-7.5, 0-2.7	0.1-3, To 3.5	Asselin *et al*., 1993; McCulloch, 2000; Pérez Tadeo *et al*., 2023; Pozo Galván *et al*., 2024.
3 groups (S1, S2, S3)	0-4	Up to 3	Nowak, 2020
Knocks/ Type 8/ Claps*	To 16, Beyond 50	To 10	Asselin *et al*., 1993; McCulloch, 2000; Hocking *et al.,* 2020; Pérez Tadeo *et al*., 2023

* Knocks (Asselin *et al.,* 1993) and call type 8 (McCulloch, 2000) are not vocalisations. These were properly described as claps by Hocking *et al.* (2020).

In contrast to Grey Seal, Harbour Seal display a distinctive yet more restrained underwater vocal behaviour pattern, particularly during breeding and mother-pup interactions. Harbour Seal are relatively sedentary, showing strong fidelity to near-shore haul-out sites such as intertidal sandbanks, rocky shores, and glacial ice flows (Bigg, 1981; Burns, 2009; London *et al.,* 2012). These sites are vital throughout the year, providing safe spaces for resting, grouping as a protective strategy, and breeding and raising pups during pupping and moulting seasons (da Silva & Terhune, 1988; Thompson, 1989). Mating takes place in the water close to their haul-out sites immediately after pups are weaned, with polygynous males engaging in underwater acoustic displays and dives to defend territory, compete with other males, and attract females (Burns & Gol'tsev, 1984; Hayes *et al.,* 2004a; Van Opzeeland *et al.*, 2008).

Male vocalisations consist primarily of broadband, nonharmonic roars, typically ranging from 0.05 to 4 kHz, that are integral to both competition and courtship (Hanggi & Schusterman, 1994; Hayes *et al*., 2004b; Van Parijs *et al.,* 1997, 1999, 2000; Table 13-3). Female Harbour Seal, by contrast, vocalise mainly to maintain contact with their pups, establishing strong bonds through frequent vocal and physical interaction during the four-week nursing period (Lawson & Renouf, 1987; Sauvé *et al.,* 2015). While less elaborate than the Grey Seal's repertoire, this vocal communication underscores the importance of acoustic signals in maintaining social bonds, navigating territorial dynamics, and securing reproductive success in Harbour Seal.

Table 13-3: Harbour Seal underwater vocalisation types (general classification). Adapted from Reynolds and Rommel (1999)

Signal type	Frequency range (kHz)	Frequency Near Maximum Energy (kHz)	References
Clicks	8-150	12-40	Cummings & Fish, 1971; Noseworthy *et al*., 1989; Renouf *et al*., 1980; Schevill *et al*., 1963
Roar	0.4-4, Beyond 6, 0-1	0.4-0.8	Hanggi & Schusterman 1992, 1994; Nikolich, 2015; Pozo Galván *et al*., 2024
Growl, grunt, groan	<0.1-4	<0.1-0.25	Hanggi & Schusterman 1992, 1994; Nikolich, 2015; Pozo Galván *et al*., 2024
Creak	0.7-4, 0-2.6	0.7-2	Hanggi & Schusterman 1992, 1994; Pozo Galván *et al*., 2024
Short call	Beyond 1	-	Nikolich, 2015
Sweep	Up to 6	-	Nikolich, 2015

13.3.2 VANTAGE POINT FIELD SURVEY RESULTS

13.3.2.1 OVERVIEW

The number of sightings and mean group size observed during effort watches are shown in Table 13-4 and detail of all sightings in Table 13-5. A total of seven species of marine mammal, including two species of pinniped and five cetacean species including four dolphin species and one whale (Table 13-4) have been observed.

Table 13-4: Summary of sightings from VP watches at Rosslare Europort (July 2022 to August 2024)

Species	No. sightings	% days with sightings	Group size Mean±SD (range)
Grey Seal	105	89.6	1.37±0.76 (1-2)
Harbour Seal	7	12.5	1

Harbour Porpoise	36	50.0	2.55±1.78 (1-3)
Bottlenose Dolphin	9	16.7	1.45±0.0.32(1-5)
Common Dolphin	4	8.3	26±12.7 (15-40)
Risso's Dolphin	4	8.3	1
Minke Whale	5	10.4	1
Total	170	100	

Grey Seal were recorded on every watch, with a maximum of seven individuals present in February (Table 13-5). A single Harbour Seal was also recorded throughout the year on a quarter (27.1%) of watches. This species was not recorded during the first year of VP watches.

Harbour Porpoise were recorded throughout the year (Table 13-5), while Bottlenose Dolphin were recorded in September, April and May and June, with Common Dolphin in October and December and single Risso's Dolphin in January, March and June. Single Minke Whale were recorded during autumn months, in October and November.

Table 13-5: Number of sightings and individual seals and cetaceans recorded during vantage point watches (July 2022 to August 2024)

Watch No.	Date	Seals		Harbour Porpoise		Dolphins		Whales	
		Sight	Individ	Sight	Individ	Sight	Individ	Sight	Individ
VP 1	19th July 2022	2 GS	2	1	1				
VP 2	23rd July 2022	1 GS	1	1	3	1 RD	1		
VP 3	18th August 2022	2 GS	3						
VP 4	27th August 2022	2 GS	2	2	5				
VP 5	12th Sept 2022	2 GS	3	1	2				
VP 6	20th Sept 2022	2 GS	3	1	2	1 BND	5		
VP 7	2nd October 2022	2 GS	3						
VP 8	23rd October 2022			1	2				
VP 9	16th November 2022	2 GS	3			1 CD	6		
VP 10	29th November 2022			1	4			1 MW	1
VP 11	7th December 2022	2 GS	3						
VP 12	20th December 2022	2 GS	3	1	3				
VP 13	18th January 2023	2 GS	2						
VP 14	28th January 2023	2 GS	2	2	5				
VP 15	21st February 2023	1 GS	1						
VP 16	23rd February 2023	1 GS	1			1 CD	6		
VP 17	20th March 2023	1 GS	1						
VP 18	27th March 2023	2 GS	2						
VP 19	13th April 2023			2	4				
VP 20	28th April 2023	2 GS	2	1	2	1 BND	1		
VP 21	24th May 2023	1 GS	1	3	9				
VP 22	29th May 2023	2 GS	2	1	3				

Watch No.	Date	Seals		Harbour Porpoise		Dolphins		Whales	
		Sight	Individ	Sight	Individ	Sight	Individ	Sight	Individ
VP 23	29th June 2023			1	2			1 SF	1
VP 24	30th June 2023			2	6				
VP 25	16th September 2023	5 GS	6						
VP 26	25th September 2023	2 GS	2			1 BND	5		
VP 27	10th October 2023	1 GS	1	2	2	1 CD	15-20		
VP 28	25th October 2023	2 GS 1 CS	2 1	1	2			1 MW	1
VP 29	9th November 2023	5 GS	5					1 MW	1
VP 30	17th November 2023	3 GS	3	1	2			1 MW	1
VP 31	4th December 2023	3 GS 1 CS	3 1						
VP 32	11th December 2023	2 GS	2			1 CD	30-40		
VP 33	15th January 2024	2 GS	2						
VP 34	26th January 2024	2 GS 1 CS	2 1			1 RD	1		
VP 35	12th February 2024	3 GS	3	2	2				
VP 36	22nd February 2024	6 GS	7						
VP 37	21st March 2024	2 GS	2	2	2				
VP 38	29th March 2024	3 GS	4	1	2	1 RD	1		
VP 39	15th April 2024	4 GS 1 CS	4 1						
VP 40	23rd April 2024	2 GS	2			1 BND	1		
VP 41	7th May 2024	2 GS	2	2	5				
VP 42	20th May 2024	1 GS	1			1 BND	1		
VP 43	11th June 2024	4 GS 1 CS	4 1	2	5	1 BND 1 RD	1 1		
VP 44	24th June 2024	3 GS	4						
VP 45	18th July 2024	4 GS	4	1	2				
VP 46	30th July 2024	3 GS 1 CS	3 1						
VP47	14th August 2024	3 GS 1 CS	3 1			2 BND	1	1 MW?	1
VP48	29th August 2024	5 GS	5			3 BND	2		

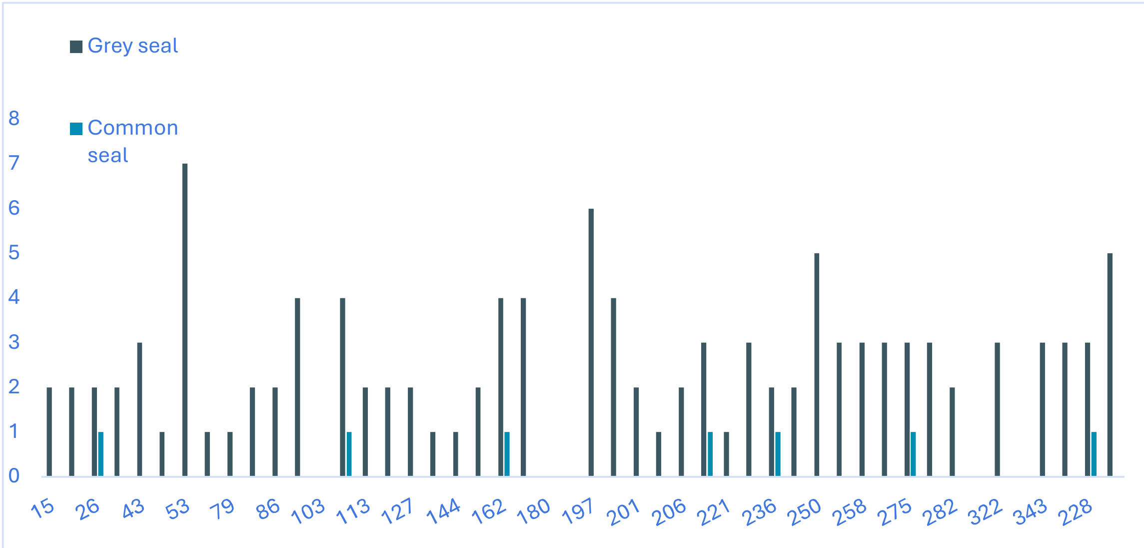


Figure 13-28: Distribution of sightings of seals per watch presented by Julian Day (1 is 1st January and 365 is 31st December)

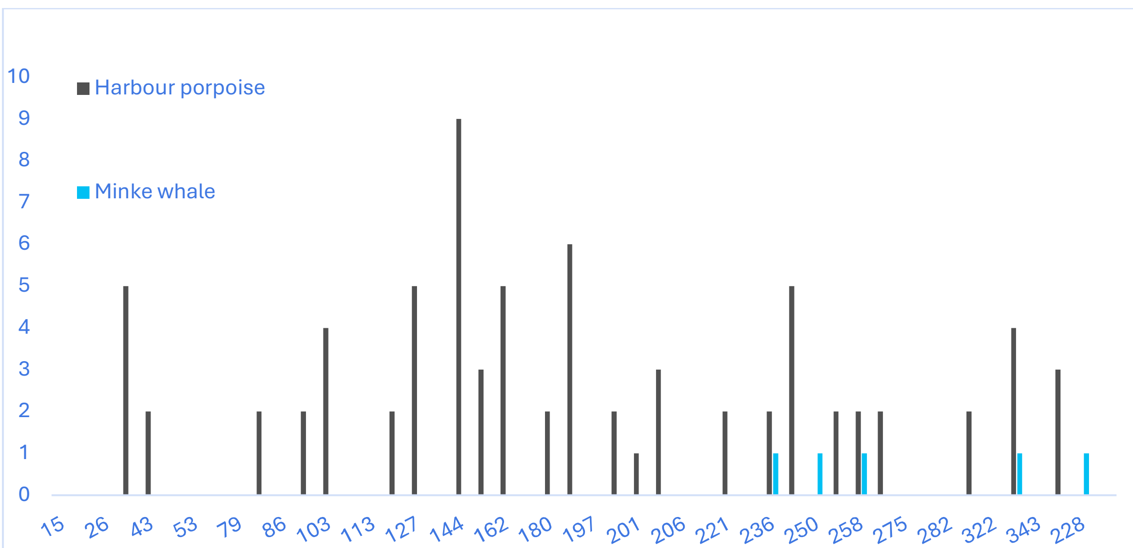


Figure 13-29: Distribution of sightings of Harbour Porpoise and Minke Whale per watch presented by Julian Day (1 is 1st January and 365 is 31st December)

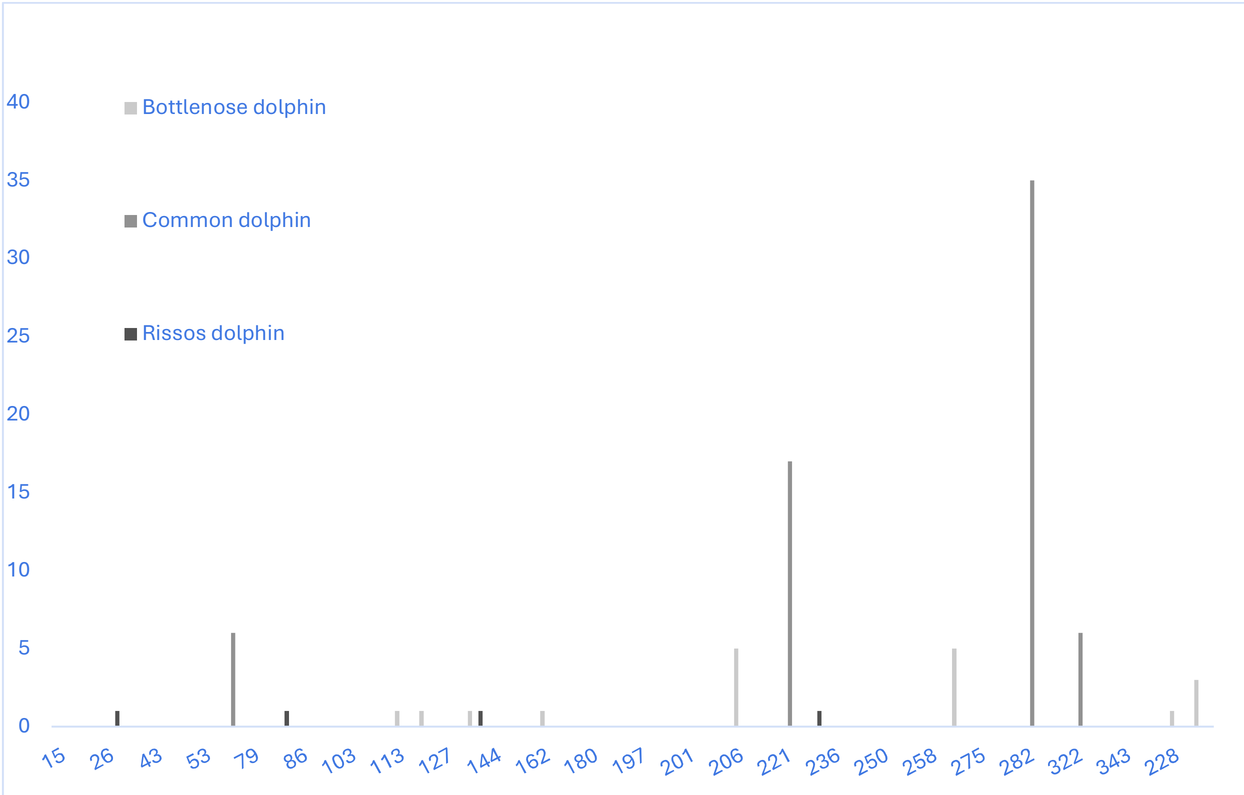


Figure 13-30: Distribution of sightings of dolphins per watch presented by Julian Day (1 is 1st January and 365 is 31st December)

13.3.2.2 SIGHTINGS WITHIN PROPOSED DEVELOPMENT BOUNDARY

Sightings of marine mammal species within the Proposed Development Boundary across all watches are presented in Figure 13-31.

Grey Seal, Bottlenose Dolphin and Harbour Porpoise have been observed within the Proposed Development Boundary, which includes the proposed dredge and reclamation areas, with only Grey Seal observed in and near to the proposed reclamation area. Bottlenose Dolphin and Harbour Porpoise sightings in the proposed dredge area are all > 500 m to the northeast of the proposed reclamation area and > 100 m to the north of the existing harbour breakwater. No other marine mammal species have been recorded within the Proposed Development Boundary.

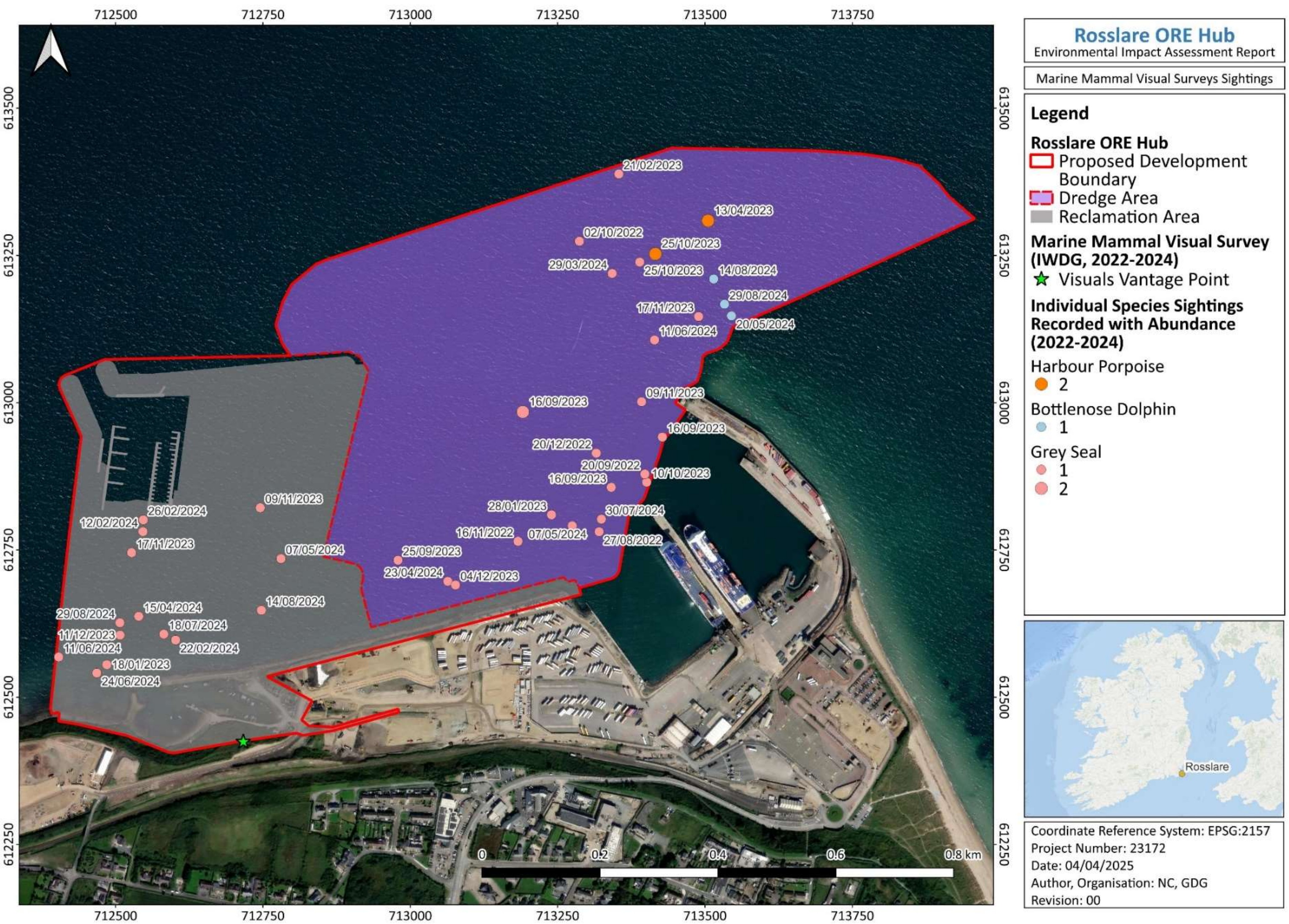


Figure 13-31: Summary of survey sightings (2022-2024) within the Proposed Development Boundary

13.3.3 SUMMARY OF EFFORT

Please note that while both survey years consisted of 12 months of fortnightly 6-hour watches, Year 1 was from 19th July 2022 to 30th June 2023 and Year 2 was from 16th September 2023 to 29th August 2024.

288 hours of watches were completed in each survey year, resulting in a total dedicated marine mammal visual survey effort of 576 hours.

Monthly ornithological surveys, also of 6-hour watch duration, were conducted from the same vantage point location by the same surveyor (Nick Veale) as the marine mammal surveys described in this report, from April 2022 to September 2024, with opportunistic marine mammal sightings recorded when observed (see Technical Appendix 14 for full details of ornithological surveys completed). Marine mammal sightings recorded between July 2023 and August 2023 are presented in Section 13.3.4.2

13.3.4 OVERVIEW BY SURVEY YEAR

13.3.4.1 VANTAGE POINT SURVEY – YEAR 1 (JULY 2022 – JUNE 2023)

The number of sightings and mean group size observed during effort watches are shown in Table 13-6 and a summary of all sightings in Table 13-7. A total of six species of marine mammal, including one species of pinniped, and a single Sunfish (*Mola mola*) were observed.

Table 13-6: Summary of sightings from Year 1 VP watches at Rosslare Europort

Species	Number of Sightings	Number of Days with Sightings	Group Size Mean±SD (range)
Grey Seal	33	19	1±0.4 (1-2)
Harbour Porpoise	19	13	3±1 (1-4)
Bottlenose Dolphin	2	2	5.5 (5-6)
Common Dolphin	2	2	6
Risso's Dolphin	1	1	1
Minke Whale	1	1	1
Sunfish	1	1	1
Total	59	39	

Harbour Porpoise and Grey Seal were recorded throughout Year 1 (Table 13-7), while Bottlenose Dolphin were recorded in September and April and Common Dolphin in November and February. A single Minke Whale was recorded offshore in November and a single Sunfish in June.

Table 13-7: Number of sightings and individual seals and cetaceans recorded during Year 1 vantage point watches (July 2022 to June 2023)

Watch No.	Date	Seals		Harbour Porpoise		Bottlenose and Common Dolphins		Others	
		Sight	Individuals	Sight	Individual s	Sight	Individuals	Sight	Individuals
VP 1	19th July 2022	2	2	1	1	0	0	0	0
VP 2	23rd July 2022	1	1	1	3	0	0	1	1
VP 3	18th August 2022	2	3	0	0	0	0	0	0
VP 4	27th August 2022	2	2	2	5	0	0	0	0
VP 5	12th Sept 2022	2	3	1	2	0	0	0	0
VP 6	20th Sept 2022	2	3	1	2	1 BD	5	0	0
VP 7	2nd October 2022	2	3	0	0	0	0	0	0
VP 8	23rd October 2022	0	0	1	2	0	0	0	0
VP 9	16th November 2022	2	3	0	0	1 CD	6	0	0
VP 10	29th November 2022	0	0	1	4	0	0	1 MW	1
VP 11	7th December 2022	2	3	0	0	0	0	0	0
VP 12	20th December 2022	2	3	1	3	0	0	0	0
VP 13	18th January 2023	2	2	0	0	0	0	0	0
VP 14	28th January 2023	2	2	2	5	0	0	0	0
VP 15	21st February 2023	1	1	0	0	0	0	0	0
VP 16	23rd February 2023	1	1	0	0	1 CD	6	0	0
VP 17	20th March 2023	1	1	0	0	0	0	0	0
VP 18	27th March 2023	2	2	0	0	0	0	0	0
VP 19	13th April 2023	0	0	2	4	0	0	0	0
VP 20	28th April 2023	2	2	1	2	1 BD	1	0	0
VP 21	24th May 2023	1	1	3	9	0	0	0	0
VP 22	29th May 2023	2	2	1	3	0	0	0	0
VP 23	29th June 2023	0	0	1	2	0	0	1 SF	1
VP 24	30th June 2023	0	0	2	6	0	0	0	0

Of a total of 59 sightings, Grey Seal were the most frequently recorded species (56%), followed by Harbour Porpoise (32%) and Bottlenose and Common Dolphin (3%). A single Minke Whale and a Risso's Dolphin were also recorded.

All species summary maps are shown below (Figure 13-32 and Figure 13-33). Summary maps for Year 1, showing the distribution of sightings per species, as well as the boundaries of the reclamation and dredge areas, are provided in Appendix A.

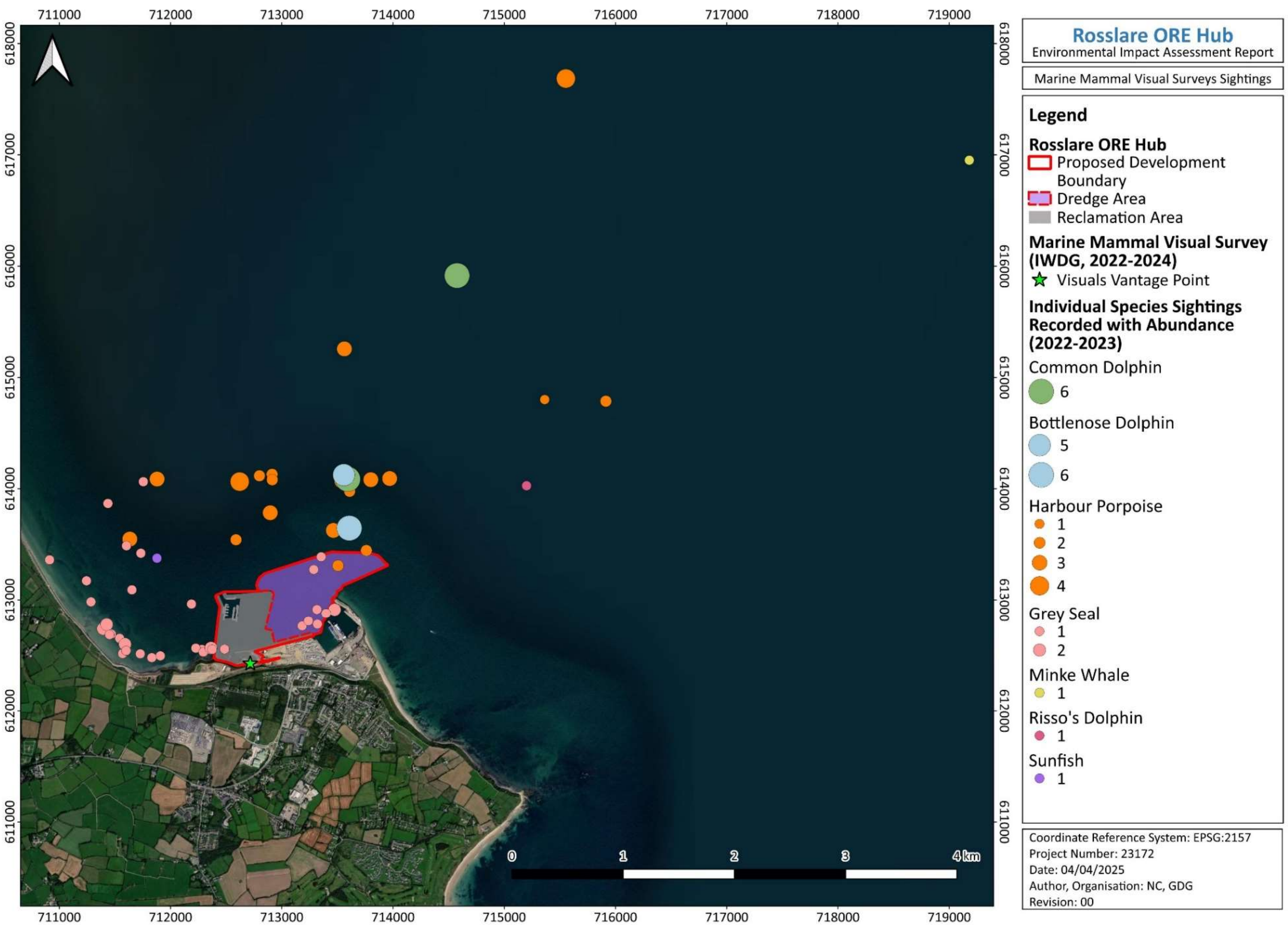


Figure 13-32: Year 1 (July 2022 - June 2023) All Marine Mammal Sightings

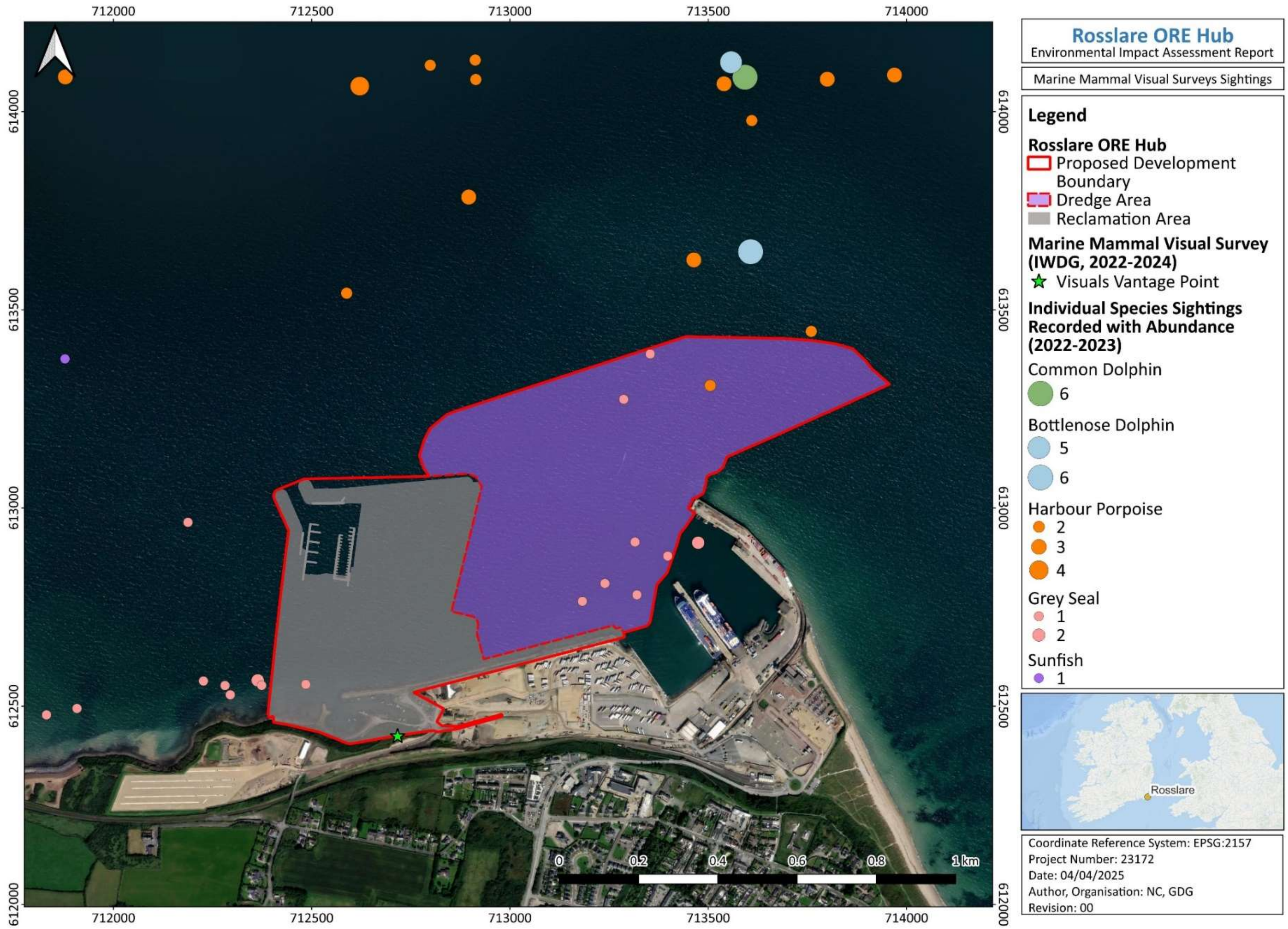


Figure 13-33: Year 1 (July 2022 - June 2023) Marine Mammal Sightings near to Proposed Development Boundary

13.3.4.2 ORNITHOLOGICAL VANTAGE POINT SURVEY; MARINE MAMMAL SIGHTINGS JULY 2023 – AUGUST 2023)

Figure 13-34 shows the spatial distribution of marine mammal sightings recorded during ornithology vantage point surveys undertaken in July and August 2023.

Three (3) Grey Seal and five (5) Harbour Porpoise were recorded in the July 2023 ornithology vantage point survey. One (1) Grey Seal and two (2) Harbour Porpoise were recorded in the August 2023 ornithology vantage point survey.

Note these sightings are consistent with the findings of the dedicated marine mammal vantage point surveys described in this report. However, the sightings are presented here separately and not included in the summary maps of marine mammal survey sightings from the dedicated marine mammal vantage point surveys, as the primary purpose and focus of the ornithological surveys was to observe and record bird sightings. As such, it is not considered scientifically valid to combine the results of these surveys.

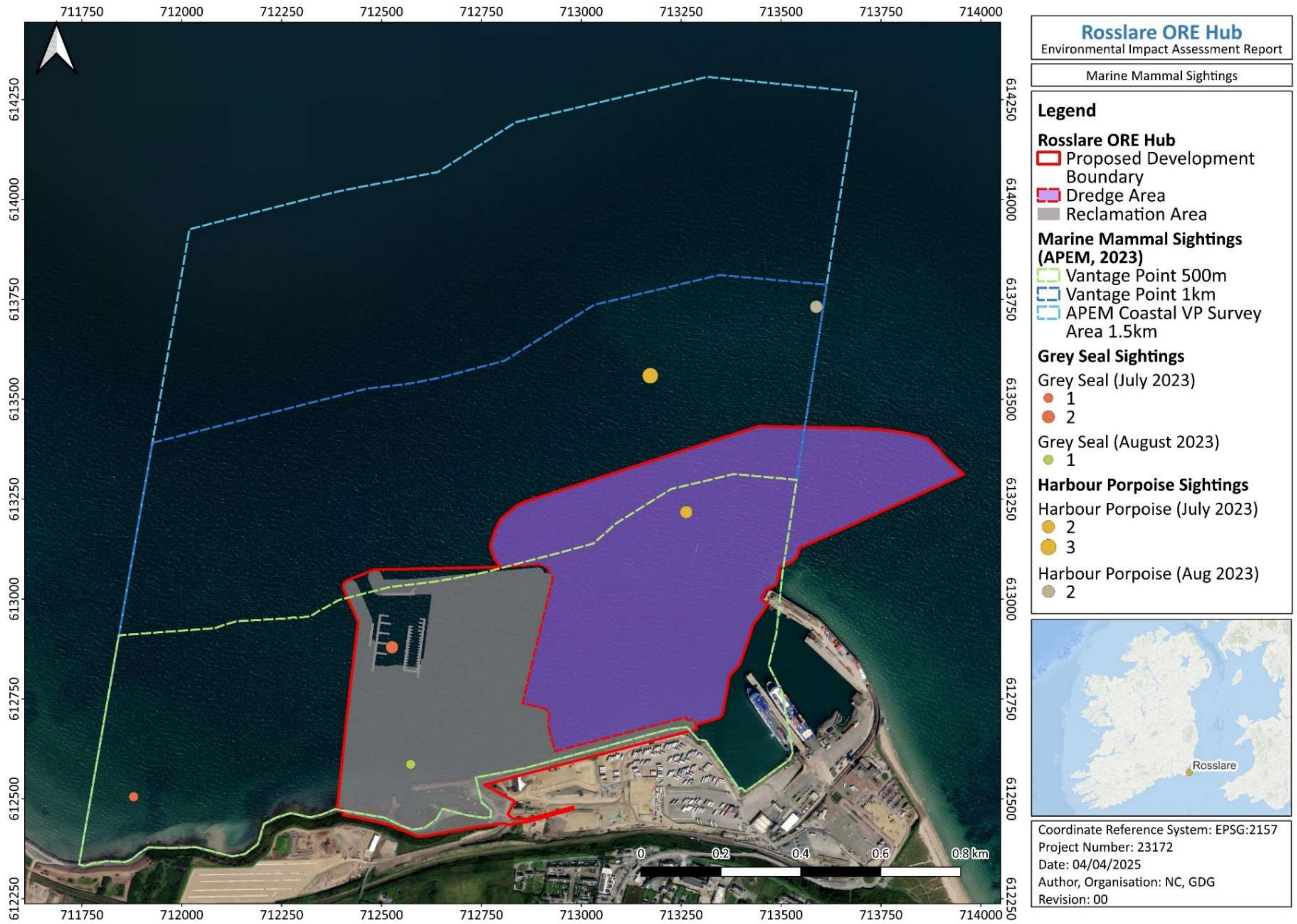


Figure 13-34: Spatial distribution of marine mammal sightings recorded in ornithology vantage point surveys conducted in July and August 2023 (from Technical Appendix 14)

13.3.4.3 VANTAGE POINT SURVEY – YEAR 2 (SEPTEMBER 2023 – AUGUST 2024)

The number of sightings and mean group size observed during effort watches are shown in Table 13-8 and a summary of all sightings in Table 13-9. A total of seven species of marine mammal were observed, including two species of pinniped and five cetacean species including four dolphin species and one whale (Table 13-8).

Table 13-8: Summary of sightings from Year 2 VP watches at Rosslare Europort (September 2023 to August 2024)

Species	No. sightings	% days with sightings	Group size Mean±SD (range)
Grey Seal	72	100	1.17±0.6 (1-2)
Harbour Seal	7	29.2	1
Harbour Porpoise	14	58.3	1.6±0.7 (1-3)
Bottlenose Dolphin	9	25.0	1.1±0.3 (1-2)
Common Dolphin	2	0.8	26±12.7 (15-40)
Risso's Dolphin	3	12.5	1
Minke Whale	4	16.7	1
Total	111		

Grey Seal were recorded on every watch, with a maximum of seven individuals present in February (Table 13-9). Single Harbour Seal were also recorded throughout the year on over a quarter (27.1%) of watches. This species was not recorded during Year 1 VP watches.

Harbour Porpoise were recorded throughout the year (Table 13-9), while Bottlenose Dolphin were recorded in September, April and May, June and August with Common Dolphin in October and December and a single Risso's Dolphin in January, March and June. Single Minke Whale were recorded during autumn in the months of October and November and a probable sighting in August (Table 13-9).

Table 13-9: Number of sightings and individual seals and cetaceans recorded during Year 2 vantage point watches (September 2023 to August 2024)

Watch No.	Date	Seals		Harbour Porpoise		Dolphins		Whales	
		Sight	Individuals	Sight	Individuals	Sight	Individuals	Sight	Individuals
VP25	16th September 2023	5 GS	6						
VP26	25th September 2023	2 GS	2			1 BND	5		
VP27	10th October 2023	1 GS	1	2	2	1 CD	15-20		

Watch No.	Date	Seals		Harbour Porpoise		Dolphins		Whales	
VP28	25th October 2023	2 GS 1 HS	2 1	1	2			1 MW	1
VP29	9th November 2023	5 GS	5					1 MW	1
VP30	17th November 2023	3 GS	3	1	2			1 MW	1
VP31	4th December 2023	3 GS 1 HS	3 1						
VP32	11th December 2023	2 GS	2			1 CD	30-40		
VP33	15th January 2024	2 GS	2						
VP34	26th January 2024	2 GS 1 HS	2 1			1 RD	1		
VP35	12th February 2024	3 GS	3	2	2				
VP36	22nd February 2024	6 GS	7						
VP37	21st March 2024	2 GS	2	2	2				
VP38	29th March 2024	3 GS	4	1	2	1 RD	1		
VP39	15th April 2024	4 GS 1 HS	4 1						
VP40	23rd April 2024	2 GS	2			1 BND	1		
VP41	7th May 2024	2 GS	2	2	5				
VP42	20th May 2024	1 GS	1			1 BND	1		
VP43	11th June 2024	4 GS 1 HS	4 1	2	5	1 BND 1 RD	1 1		

Watch No.	Date	Seals		Harbour Porpoise		Dolphins		Whales	
VP44	24th June 2024	3 GS	4						
VP45	18th July 2024	4 GS	4	1	2				
VP46	30th July 2024	3 GS 1 HS	3 1						
VP47	14th August 2024	3GS 1HS	3 1			2BND	1	1 MW?	1
VP48	29th August 2024	5GS	5			3BND	2		

All species summary maps are shown below (Figure 13-35 and Figure 13-36). Summary maps for Year 2, showing the distribution of sightings per species, as well as the boundaries of the reclamation and dredge areas, are provided in Appendix A.

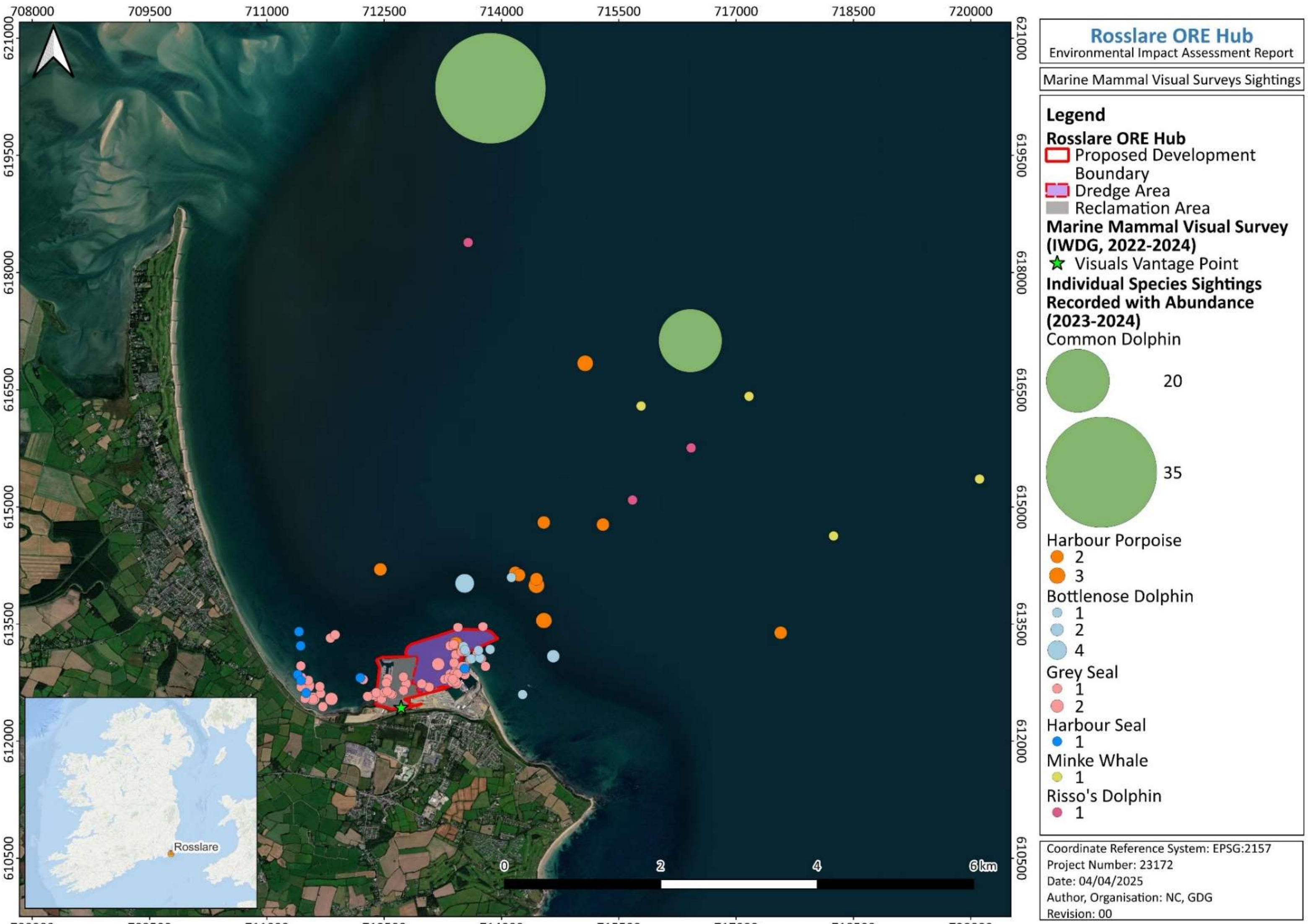


Figure 13-35: Year 2 (September 2023 – August 2024) All Marine Mammal Sightings

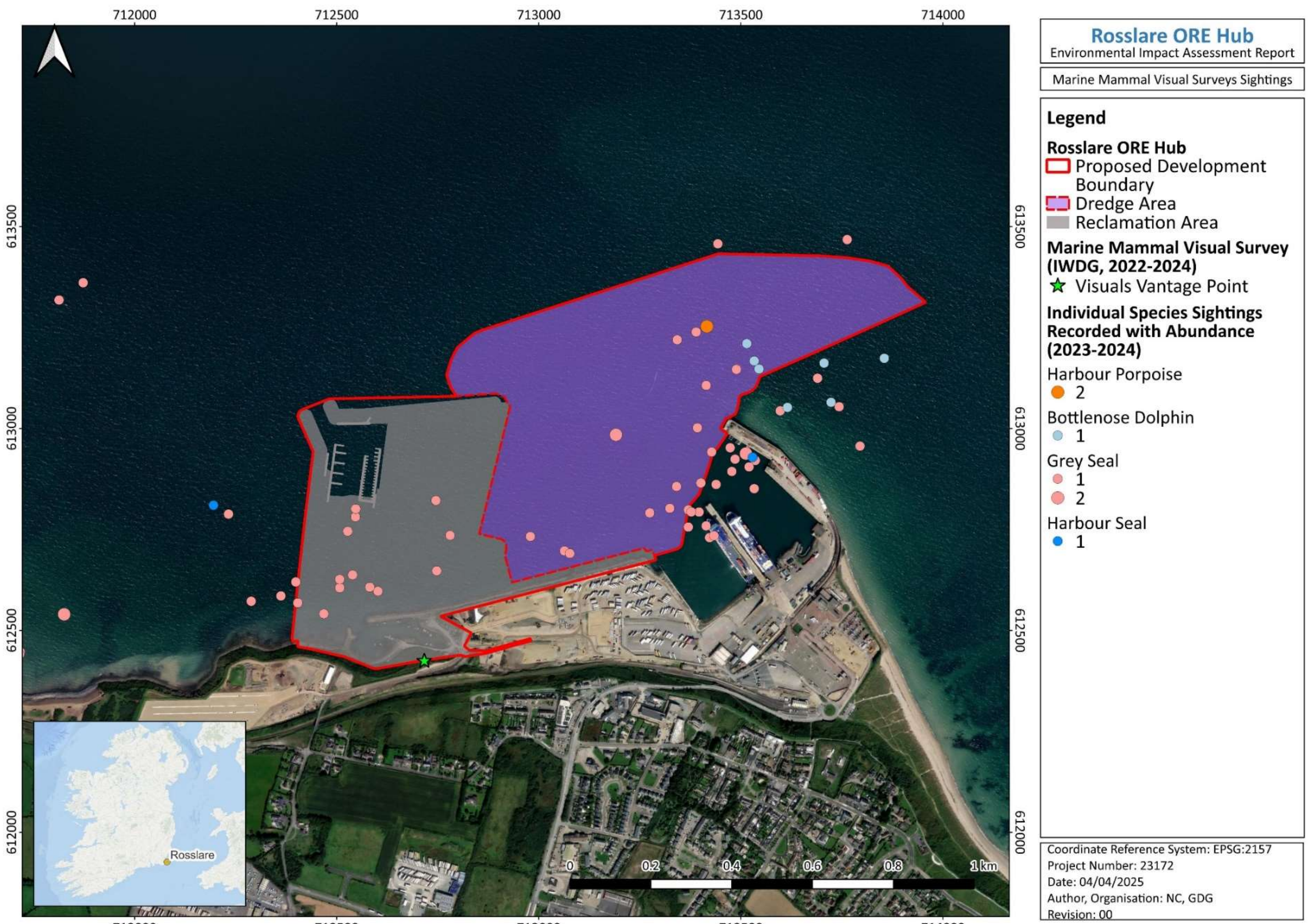


Figure 13-36: Year 2 (September 2023 – August 2024) Marine Mammal Sightings near to Proposed Development Boundary

13.3.5 SAM FIELD SURVEY RESULTS

13.3.5.1 OVERVIEW

SAM data showed the area is used almost daily by dolphin species and porpoises, however detections were more frequent at Site 1. Site 1 is located further away from the shipping channel and in shallower water. Total detections of Common Dolphin, Bottlenose Dolphin and Harbour Porpoise ranged from 1-454 clicks per day across both locations, where the mean dolphin Detection Positive Minutes (dolphin DPM) at Site 1 was 25.6 compared with 19.6 at Site 2, off the breakwater. The mean number of porpoise detections (porpoise DPM) per day was 25.4 at Site 1 and 10.7 at Site 2. After the FPODs were collected in December 2024, statistical analyses were conducted in January and February 2025.

Ambient sound levels were quantified in 1/3-octave bands, focusing on the 63Hz and 125Hz-centred frequency bands as recommended by the MSFD (Dekeling *et al*., 2015; Picciulin *et al*., 2016). The daily average Sound Pressure Levels (SPLs) for the 63Hz band ranged from 94.1 to 107.3 dB re 1 µPa, with an average of 101.7 dB re 1 µPa. For the 125Hz band, daily averages ranged from 81.9 to 96.3 dB re 1 µPa, with an average of 89.2 dB re 1 µPa. When compared with levels recorded in other Irish waters, mean SPLs recorded at Rosslare Harbour were lower than those reported in Galway Bay and Dublin Bay but higher than in the Shannon Estuary. This study provides high-resolution, site-specific data to inform mitigation management plans.

Grey Seal showed an extensive use of the study area, with a total of 6,720 vocalisations detected during the whole SoundTrap deployment. Although less common in the area, adult (35 detections) and pup (11 detections) Harbour Seal vocalisations were detected. Both species exhibit diverse behaviours and site usage patterns.

13.3.5.2 F-PODS

SAM was carried out at two locations using F-PODs for a total of 377 days at Site 1 (14th December 2023 – 14th December 2024) and 286 days at Site 2 (14th December 2023 – 28th September 2024; Figure 13-37; Table 13-10). Detections in the NBHF range (Harbour Porpoise) were recorded on 72% of days at Site 1 and 51% of days at Site 2. Detections ranged from 1-454 per day across locations. This showed the area is regularly used by Harbour Porpoise.

Similarly, dolphins were recorded on 73% of days at Site 1 and on 78% of days at Site 2, however the total number of detections across all species was significantly less, with only 50% of the detections at Site 1. The mean dolphin detection positive minutes at Site 1 was 25.6 compared with 19.6 at Site 2, while the mean number of porpoise detections per day was 25.4 at Site 1 and 10.7 at Site 2. The results show a similar number of detection positive days but both dolphins and porpoise tended to spend longer at Site 1. Site 1 is located further away from the shipping channel (700m) and is in shallower water (5-7m). A decline in detections through the 6-month monitoring period is apparent.

Table 13-10: Summary of results from SAM at Site 1 and Site 2

Location	# days	# detections	% DPM days	Porpoise			Dolphin		
				# detections	% DPM days	Mean DPM	# detections	% DPM days	Mean DPM
Site 1	377	19,621	92	9,596438	72	25.4	10,025	73	25.6
Site 2	286	8,589	90	3,041	51	10.7	5,5481	78	19.6

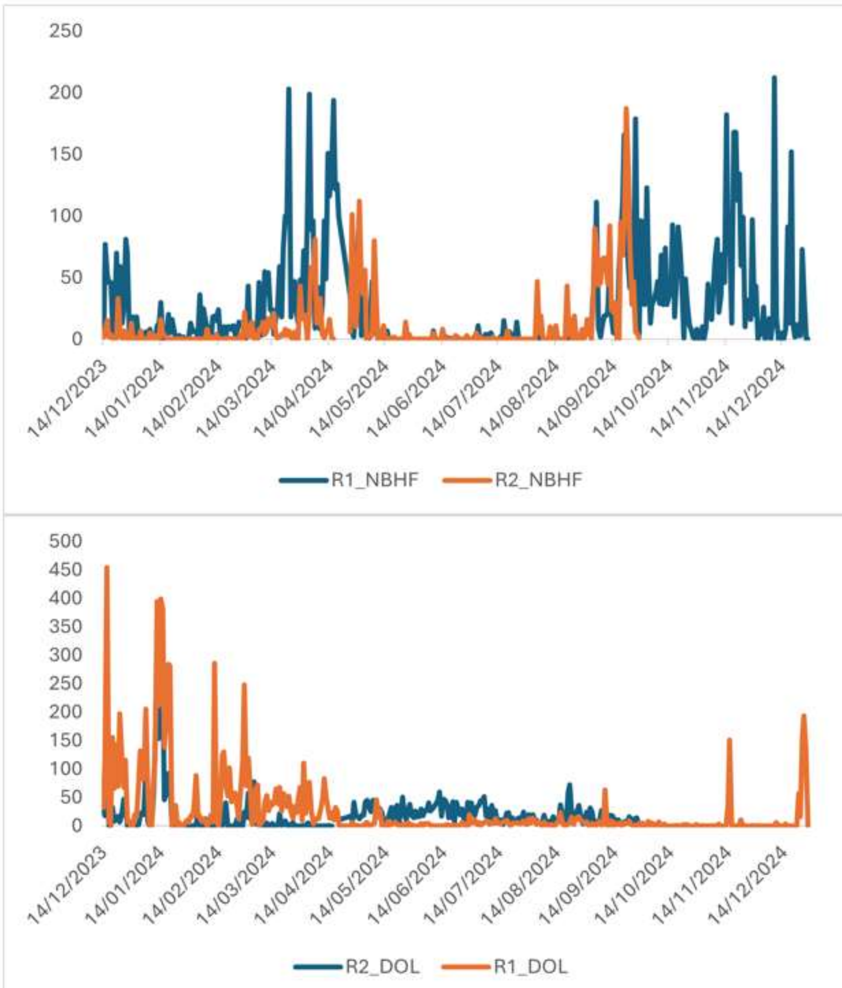


Figure 13-37: Summary of results from Rosslare 1 and Rosslare 2. NBHF = Harbour porpoise DPM per day (top) and DOL = Dolphin DPM (bottom) (14/12/2023 - 14/12/2024. Date is the X-axis on both graphs and total detections is on the Y-axis.

13.3.5.3 SOUNDTRAP

13.3.5.3.EQ. (.13)AMBIENT NOISE

Over the full SoundTrap deployment period (21st April to 2nd July 2024), recordings were collected over 72 days, on a duty cycle of 30 minutes of recordings captured every hour. From these recordings, 15 minutes per hour were selected using the tuneR package in R (Kuhn, 2024) for further analysis to assess ambient sound levels and provide a baseline for the area.

Overall, the daily average Sound Pressure Levels (SPLs) were highest in the lower frequency bands, specifically in the 1/3 octave bands centred at 31, 39, 50, and 63 Hz, with mean SPLs of 98.7, 103, 103, and 102 dB re 1µPa, respectively (Figure 13-38). The highest levels in the lower frequency bands most likely correspond to shipping traffic in the area as the frequency range 0.01-1kHz is commonly used for shipping noise assessments (Merchant *et al*., 2012). Daily average SPLs were lower and more uniform in the higher frequency bands: between the 1/3 octave band centred at 3 and 40kHz, with average SPL ranging from 81.1 to 88.5 dB re 1µPa (Figure 13-38).

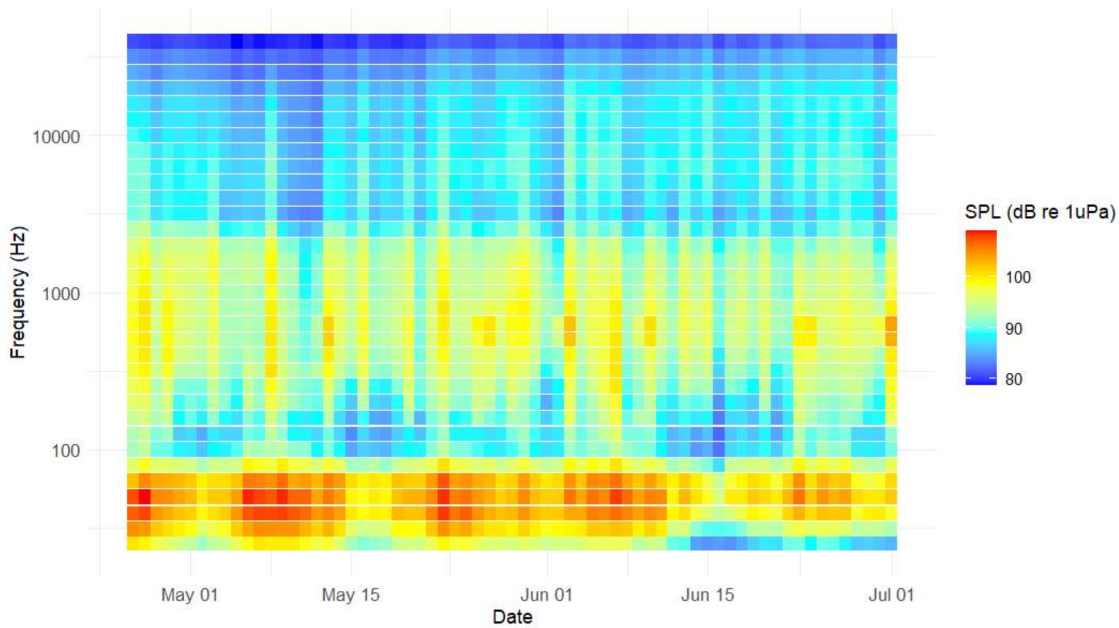
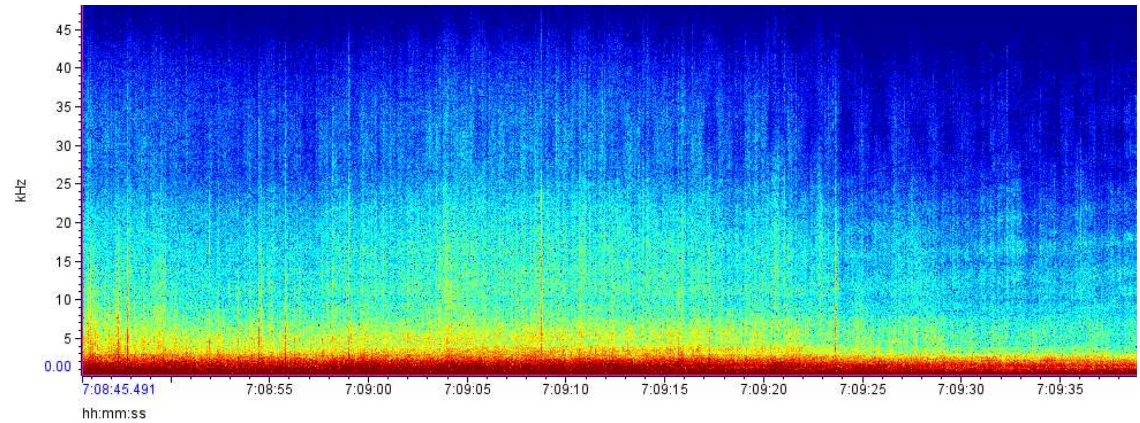


Figure 13-38: Spectrogram of daily average Sound Pressure Levels (SPLs) across 1/3 octave frequency bands

The soundscape at the Rosslare Europort ORE Hub Development was shaped by a range of factors, including oceanographic elements such as tidal movements and waves, environmental influences like rain and wind, biological contributions from dolphin whistles, clicks, and burst pulses, and anthropogenic noise from ships. Examples of spectrograms generated from the acoustic recordings at this site are presented in Figure 13-39.

A)


kHz
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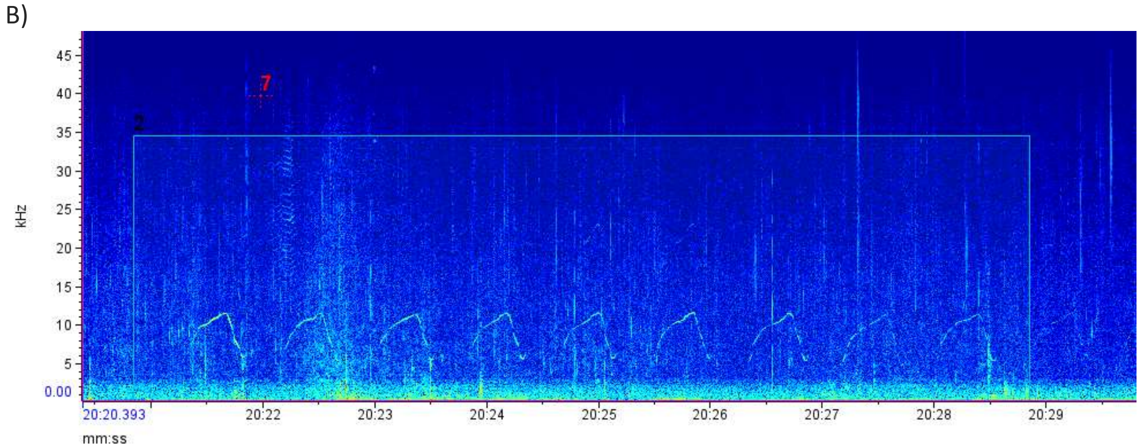
B)


kHz
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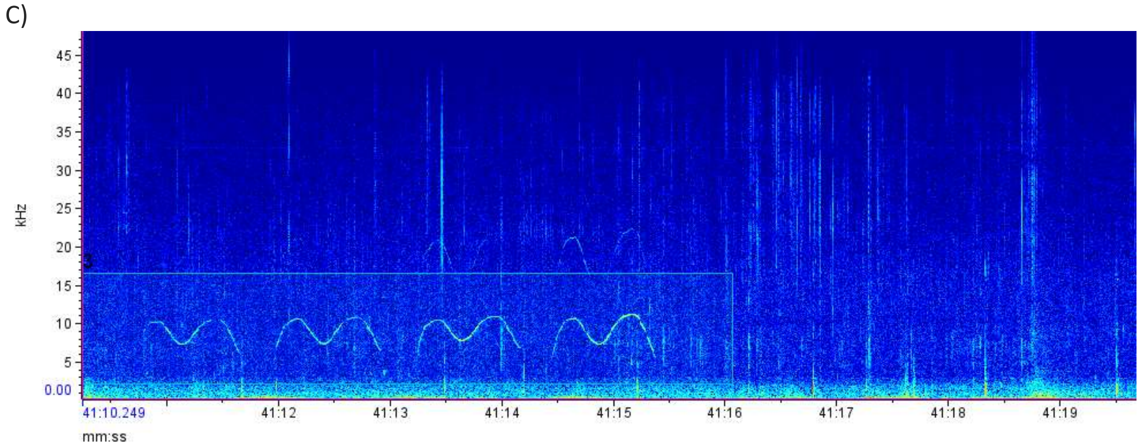
C)


kHz
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D)

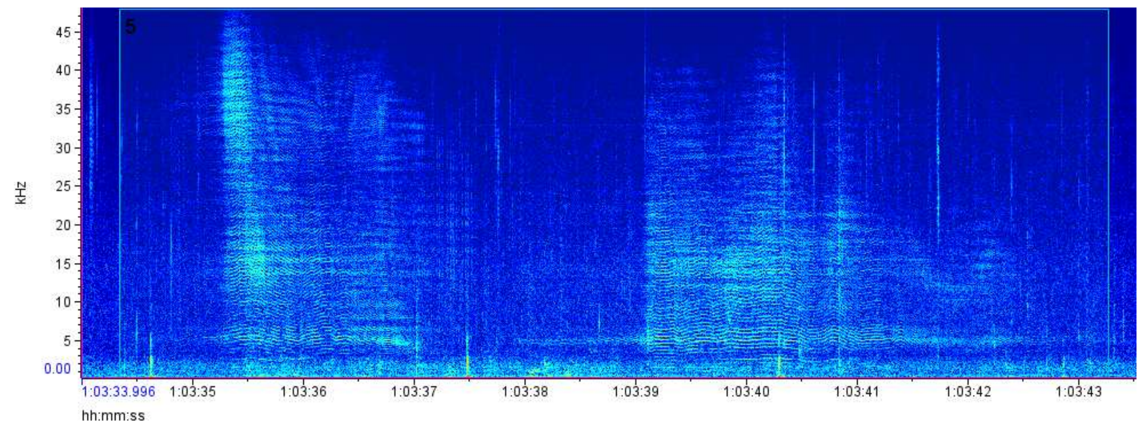

Figure 13-39: Examples of underwater sounds recorded at Rosslare Europort on 06/05/2024 and visualised using the RavenPro software, showing frequency over time. From top to bottom: vessel noise (A), dolphin whistles (B and C), and dolphin burst pulses (D).

Daily average SPLs for the 63Hz-centred frequency band ranged from 94.1 to 107.3 dB re 1µPa, with an overall average value of 101.7 dB re 1µPa (Figure 13-40). Daily average SPLs for the 125Hz-centred frequency band ranged from 81.9 to 96.3 dB re 1µPa, with an overall average value of 89.2 dB re 1µPa (Figure 13-40).

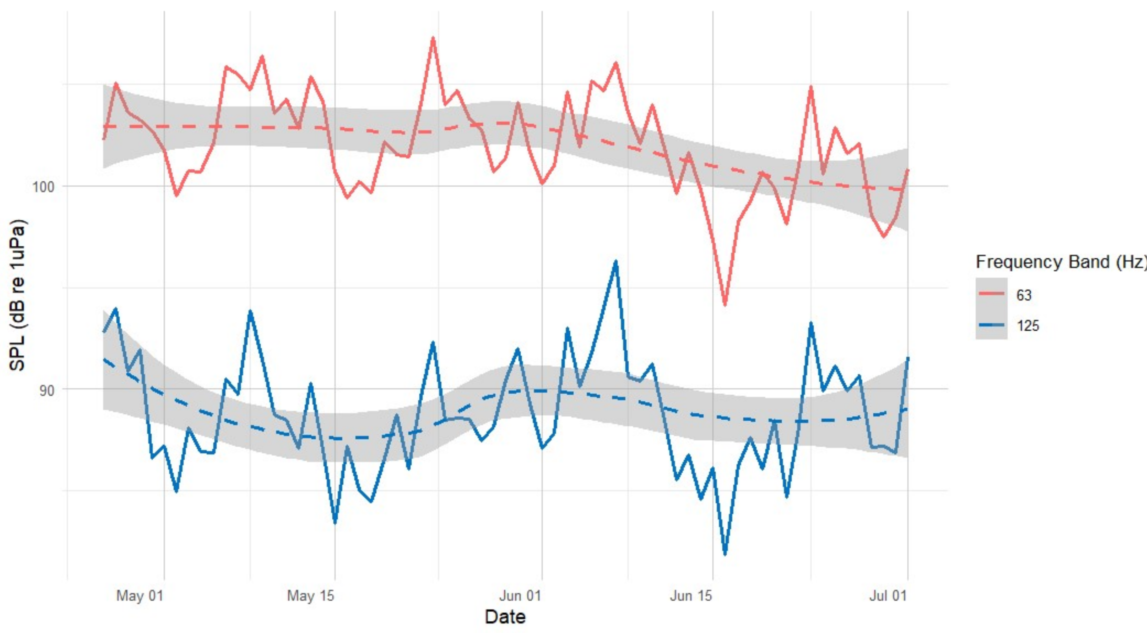

Figure 13-40: Daily average Sound Pressure Levels (SPLs) for the 63 and 125 Hz-centred frequency bands over the sampling period

13.3.5.3.EQ. (.14)SEAL VOCALISATIONS

A total of 6,720 Grey and 46 Harbour Seal vocalisations were detected over the SoundTrap deployment period (Table 13-11). Seal vocalisations were classified by species following the methodology of Pozo Galván *et al.* (2024), as specified in Section 13.2.2.3.Eq. (.5).

Table 13-11: Summary of detections from SoundTrap analysis at Rosslare Europort (April – July, 2024)

Species	Number of Detections	Number of Days with Detections
Grey seal	6720	44
Harbour seal	46	13
Total	6766	45*

* There were 12 days when both species were detected

Grey Seal

Grey Seal were recorded throughout the entire deployment, exhibiting a variety of vocalisations.

Vocalisation types were assigned to the following 10 categories, with up to four (4) subcategories assigned to each respective category (typical spectrograms for each category as well as quantitative descriptions of each Grey Seal call are provided in Appendix C):

- Type 1 "Guttural rupe"
- Type 2 "Rupe" (subtypes A, B, C and D)
- Type 3 "Trrot"
- Type 4 (subtypes A, B and C)
- Type 5
- Type 6 "Moan"
- Type 7
- Type 8 "Growl" (subtype A and B)
- Type 9 "Cry"
- Type 10 "Pop"

Note only adult Grey Seal calls were detected. This is not unexpected considering Grey Seal pupping season begins in Autumn. Call type and number of detections per type differed between day and night (

Figure 13-41), by month (

Figure 13-42), as well as under different tidal states (Figure 13-43). Rupes (subtypes A and B) were the most common vocalisations, followed by moans and guttural rupes.

Vocalisation type	Cry	Growl A	Growl B	Guttural rupe	Moan	Pop	Rupe A	Rupe B	Rupe C	Rupe D	Trrot	Type 4A	Type 4B	Type 4C	Type 5	Type 7
Total N	*3*	*2*	*19*	*83*	*403*	*31*	*4512*	*1552*	*22*	*13*	*41*	*25*	*5*	*1*	*7*	*1*

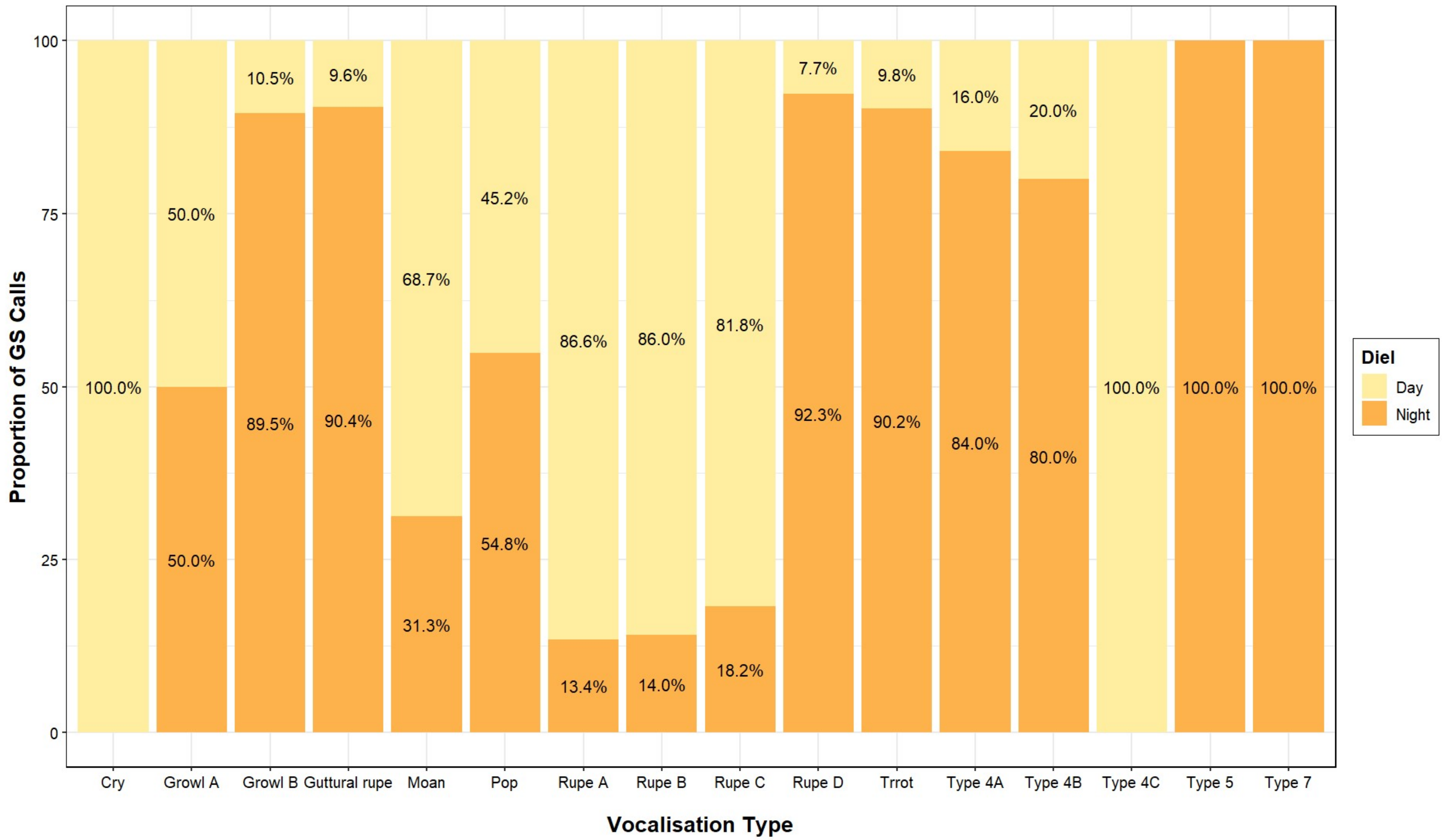

Figure 13-41: Proportion of Grey Seal calls for each vocalisation type recorded during day and night. The total number of detections (Total N) per vocalisation type is given along the top.

Vocalisation type	Cry	Growl A	Growl B	Guttural rupe	Moan	Pop	Rupe A	Rupe B	Rupe C	Rupe D	Trrot	Type 4A	Type 4B	Type 4C	Type 5	Type 7
Total N	*3*	*2*	*19*	*83*	*403*	*31*	*4512*	*1552*	*22*	*13*	*41*	*25*	*5*	*1*	*7*	*1*

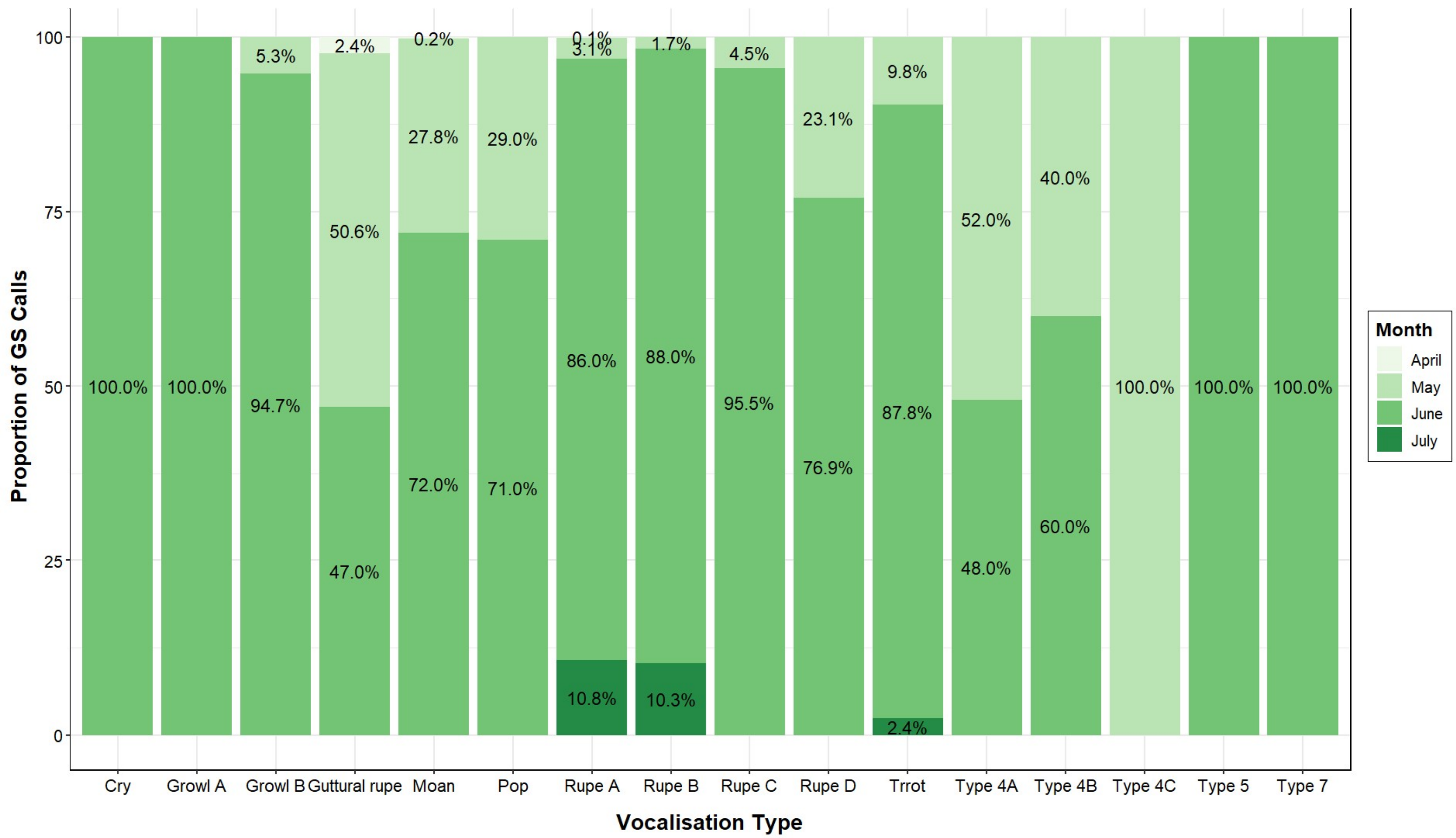

Figure 13-42: Proportion of Grey Seal calls for each vocalisation type recorded per month. Note: Small sample size for the months of April and July, with only 3 and 2 days of detections, respectively. It should be pointed out the relatively high proportion of calls, such as Rupes A and B, recorded within just two days in July.

Vocalisation type	Cry	Growl A	Growl B	Guttural rupe	Moan	Pop	Rupe A	Rupe B	Rupe C	Rupe D	Trrot	Type 4A	Type 4B	Type 4C	Type 5	Type 7
Total N	*3*	*2*	*19*	*83*	*403*	*31*	*4512*	*1552*	*22*	*13*	*41*	*25*	*5*	*1*	*7*	*1*

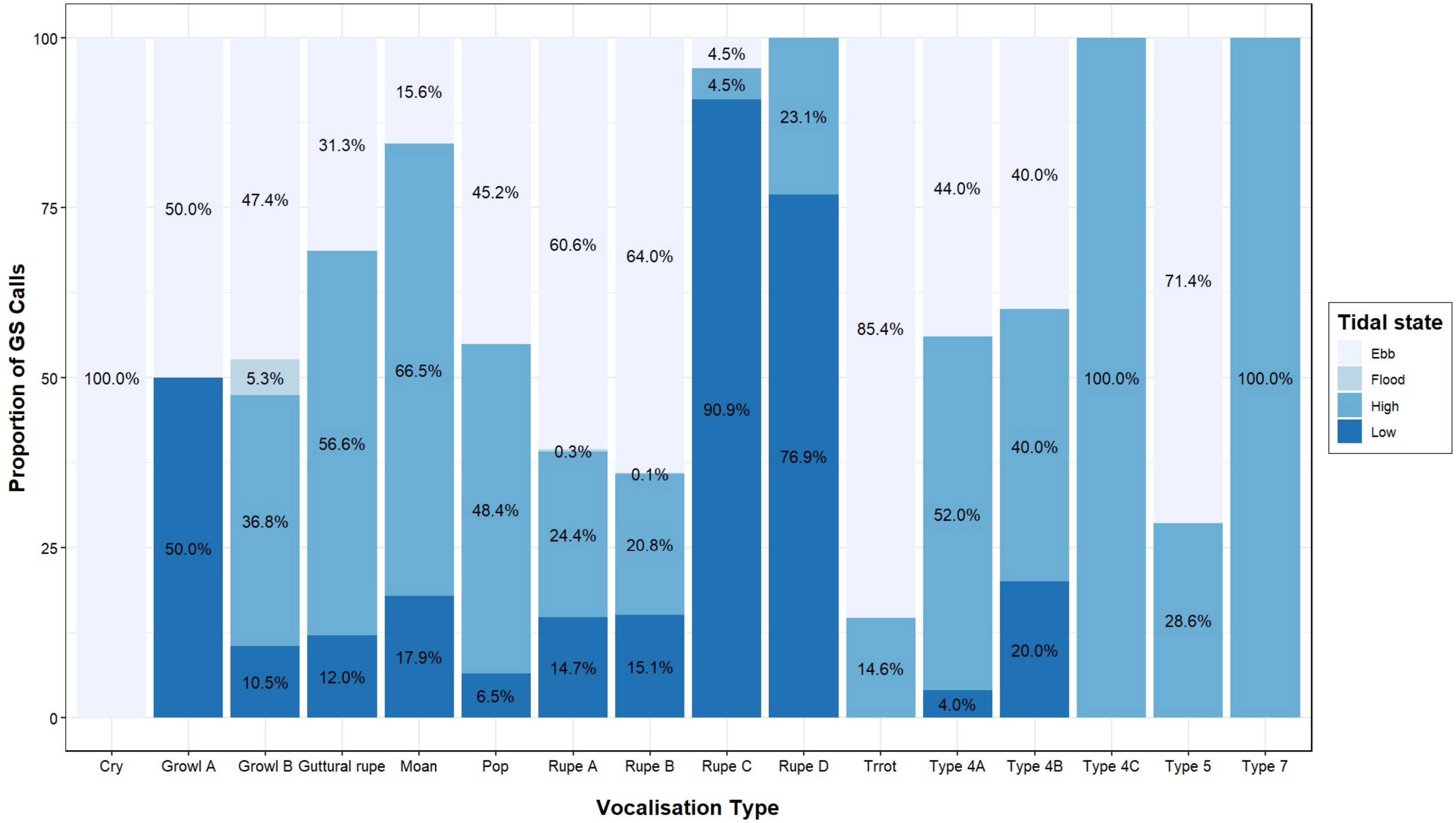

Figure 13-43: Proportion of Grey Seal calls for each vocalisation type recorded per tidal state. The total number of detections (Total N) per vocalisation type is given along the top.

Mean (± Standard Deviation, SD) of vocalisation rate per diel phase, month and tidal state were calculated. The mean Grey Seal vocalisation rate was higher during the day at 9.04 ±6.65 calls/min (n = 5574), than during the night, 2.47 ±2.54 calls/min (n = 1146). Although these differences in means appear substantial, the data were not normally distributed, so a Wilcoxon rank-sum test was used for statistical comparison. The test revealed a significant difference in vocalisation rates between day and night (p-value = 5.66 $x10^{-305}$; Figure 13-44).

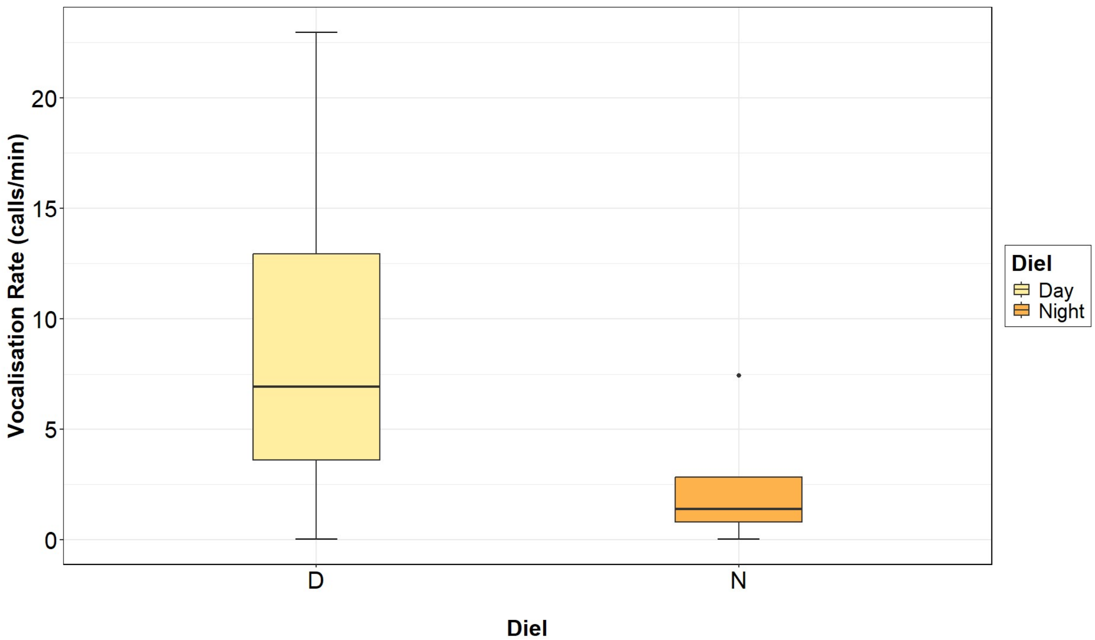

Figure 13-44: Grey Seal vocalisation rate (calls per minute) recorded in Rosslare Europort per day and night

The number of vocalisations per minute was also significantly higher in June (7.99 ± 6.57 calls/min, n = 5711) compared to May (1.07 ± 0.57 calls/min) (Wilcoxon rank-sum test, p-value= 2.5 $x10^{-156}$; Figure 13-45). Despite the exclusion from statistical analysis, vocalisation rates in July were relatively high (11.15 ± 6.12 calls/min, n = 647), suggesting a potential peak in activity that may be linked to seasonal patterns.

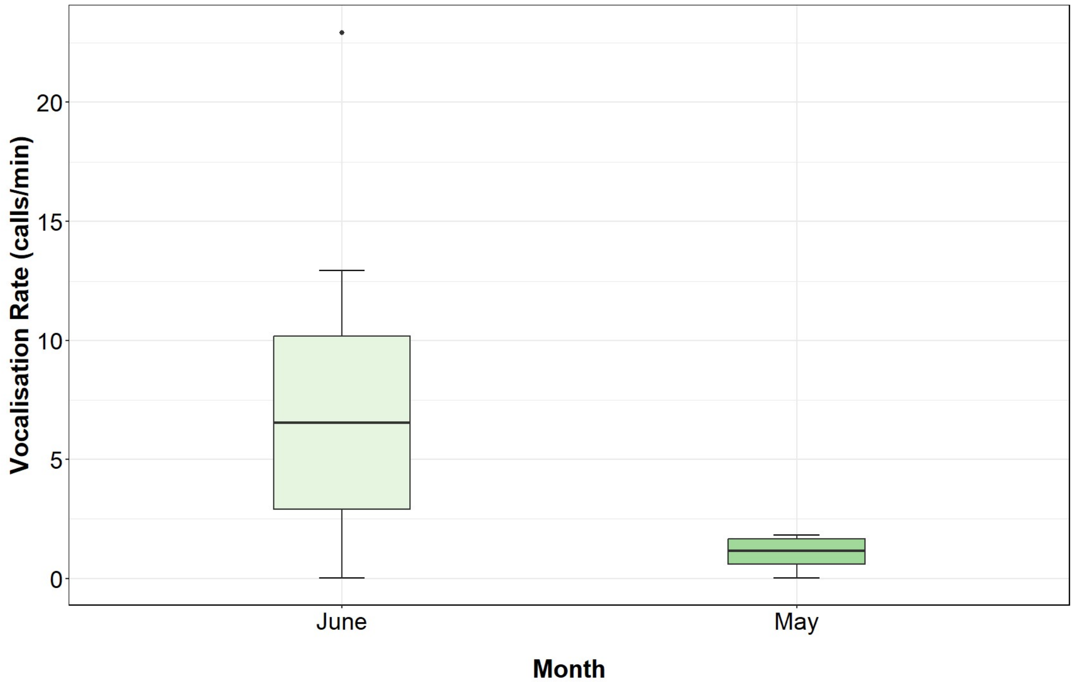

Figure 13-45: Grey Seal vocalisation rate (calls per minute) recorded in Rosslare Europort per month. Note: April and July were excluded from the analysis due to the small sample size.

Similarly, Grey Seal vocalisation rates varied significantly across tidal states, with the highest rates occurring during Ebb (10.17 ± 7.18 calls/min, n = 3897), followed by Low (5.75 ± 5.67 calls/min, = 1017) and High (4.33 ± 2.73 calls/min, n = 1790) tides. The lowest vocalisation rates were observed during Flood (0.32 ± 0.14 calls/min, n =16) (Figure 13-46). All pairwise comparisons were statistically significant ($p < 0.001$; see Appendix C for details).

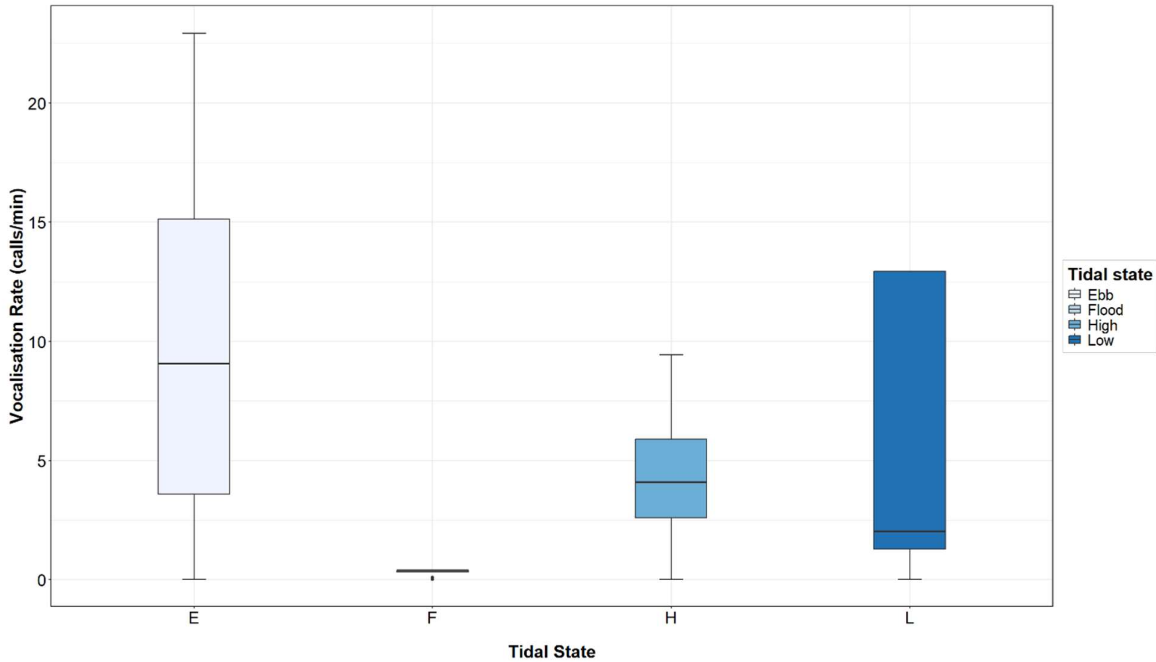

Figure 13-46: Grey Seal vocalisation rate (calls per minute) recorded in Rosslare Europort per tidal state. Note: these results should be interpreted with caution, as sample sizes varied considerably across tidal states, especially for flood tide (n = 16), which may limit the reliability fo the mean.

Harbour Seal

Although less common in the area, adult (35 vocalisations; Table 13-12) and pup (11 vocalisations; Table 13-13) Harbour Seal vocalisations were detected and classified into 7 categories. Typical spectrograms for each category as well as quantitative descriptions of each Harbour Seal call are provided in Appendix C. Note adult and pup calls were differentiated by differences in shape, frequency, call structure, duration and sound.

- Roar
- Growl
- Bubbly Growl
- Creak
- Grunt
- Pup – Typical call
- Pup – Aggressive

For Harbour Seal calls 85.71% were detected during the day, with 90.91% of pup calls detected during the night.

Table 13-12: Number of vocalisations displayed by adult Harbour Seal per month

Call type	May	June
Roar	9	5
Growl	4	6
Bubbly Growl	0	6
Creak	0	1
Grunt	2	2
Total	15	20

Table 13-13: Number of vocalisations displayed by Harbour Seal pups per month

Call type	May	June
Pup - Typical	7	2
Pup - Aggressive	1	1
Total	8	3

Note further analysis of Harbour Seal vocalisations was not undertaken owing to the small sample size. For example, for adult calls, Harbour Seal were only detected on two (2) days in May and five (5) days in June and when present, the number of detections was consistently low.

13.4 DISCUSSION AND CONCLUSION

13.4.1 VP SURVEYS

The marine mammal community in the vicinity of the Proposed Development at Rosslare Europort has been described from historical data and site-specific vantage point survey data collected between July 2022 and August 2024.

The review of historical data undertaken indicates that the south-east coast of Ireland, where the Proposed Development is located, is of most importance for Harbour Porpoise, Bottlenose Dolphin, Grey Seal and Harbour Seal, with other cetaceans including Minke Whale, Risso's Dolphin, Common Dolphin, White-beaked Dolphin and White-sided Dolphin observed in the area less frequently.

The Proposed Development Boundary does not directly overlap with but is close to four SACs designated for the protection of marine mammal species. In March 2024, Harbour Porpoise was added as a QI to Carnsore Point SAC, which is 1.4 km from the Proposed Development Boundary, and Blackwater Bank SAC, which is 4.9km from the Proposed Development Boundary. The Slaney River Valley SAC has regionally significant numbers of Harbour Seal and is 6.6 km north from the Proposed Development. An important breeding, pupping and haul out site for Grey Seal occurs on the Saltee Islands SAC on Great Saltee, which is 21 km from the Proposed Development.

A moderately diverse community has been recorded over the course of the site-specific vantage point surveys undertaken, with Harbour Porpoise frequently occurring, Common and Bottlenose Dolphin infrequent and Minke Whale and Risso's Dolphin rare. Grey Seal were frequently recorded (including on every watch in Year 2) and Harbour Seal were also recorded. Harbour Porpoise and Grey Seal occurred throughout the year.

The 24-months of dedicated fortnightly marine mammal vantage point surveys undertaken show that Grey Seal, Bottlenose Dolphin and Harbour Porpoise have been observed within the Proposed Development Boundary, which includes the Proposed Dredge and Reclamation Areas, with only Grey Seal observed in and near to the Proposed Reclamation Area (Figure 13-31). Bottlenose Dolphin and Harbour Porpoise sightings in the Proposed Dredge Area are all > 500 m to the northeast of the proposed reclamation area and > 100 m to the north of the existing harbour breakwater. No other marine mammal species have been recorded within the Proposed Development Boundary. This is further supported by the opportunistic marine mammal sighting recorded during the ornithological vantage point surveys completed in July and August 2023 (Figure 13-34), when no dedicated marine mammal vantage point surveys were completed.

13.4.2 CETACEANS AND AMBIENT NOISE

Cetaceans live in an acoustic world and acoustic monitoring techniques are used increasingly to monitor their presence and behaviour, rather than relying on visual methods, where efficacy is dependent on light, weather conditions and sea-state, especially for species such as the harbour porpoise. The reliance on sound by these animals is extremely important and therefore SAM is a valuable tool for assessing fine-scale habitat use by various odontocete species.

SAM provides information on species that can go undetected visually for up 95% of the time (e.g. Harbour Porpoise; Read & Westgate, 1995).

A SoundTrap was used to assess the soundscape and provide baseline ambient noise levels at Rosslare Europort. As recommended by the MSFD, SPLs from the 63 and 125 Hz-centred 1/3 octave frequency bands were examined for continuous low-frequency sound (Dekeling *et al*., 2015; Picciulin *et al*., 2016). The mean SPLs we recorded for the 63Hz and 125Hz-centred 1/3 octave bands were 101.7 and 89.2 dB re 1µPa, respectively.

When compared with levels recorded in other Irish waters, mean SPLs recorded at Rosslare Harbour were lower than those reported in Galway Bay (103.1 dB re 1µPa) and Dublin Bay (between 125 dB and 135 dB dB re 1µPa across all frequency bands) by Beck *et al.* (2013), but higher than in the Shannon Estuary, where mean noise levels recorded were 100 dB re 1µPa (Table 13-14).

When comparing to Scottish waters, van Geel *et al.,* (2022) found that the median SPLs for the 125Hz-centred 1/3 octave band across various arrays ranged from 75 to 95 dB re 1µPa in the Outer Hebrides, which are lower than the levels recorded at Rosslare Europort. Merchant *et al.,* (2016) also reported lower median noise levels ranging between 81.5 dB and 95.9 dB re 1 µPa for 1/3 octave bands from 63 Hz to 500 Hz at different sites in the UK during 2013-2014 (Table 13-14). Furthermore, the SeaMonitor project reported mean noise levels in the North Channel ranging from 80 to 120 dB re 1 µPa for the 125 Hz-centred 1/3 octave band (Pommier & O'Brien, 2023), and our measured mean level of 89.2 dB re 1 µPa falls within this range (Table 13-14). These baseline levels will serve as a critical reference for future monitoring and impact assessments, helping to evaluate changes in the soundscape over time.

Table 13-14: Average and/or range of Sound Pressure Levels (SPLs) recorded at different locations across Irish and UK waters

Location	SPL (re 1µPa)	1/3 octave band	Reference
Rosslare Harbour	101.7 (94.1 - 107.3)	63Hz-centred	O'Brien *et al*. (2024)
	89.2 (81.9 - 96.3)	125Hz-centred	
Galway Bay	103.1	Across all bands	Beck *et al*. (2013)
Dublin Bay	125 - 135	Across all bands	Beck *et al*. (2013)
Shannon Estuary	100	Across all bands	Beck *et al*. (2013)
Outer Hebrides	75 - 95	125Hz-centred	Van Geel *et al*. (2022)

Location	SPL (re 1µPa)	1/3 octave band	Reference
Different sites across the UK	81.5 - 95.9	from 63Hz to 500Hz-centred	Merchant *et al.* (2016)
North Channel	80 - 120	125Hz-centred	Pommier and O'Brien (2023)

13.4.3 SEALS

Both Harbour and Grey Seal were acoustically detected within the study area. A relatively smaller number of Harbour Seal vocalisations were detected compared to Grey Seal vocalisations, consistent with the relative detection rates of these species recorded during visual vantage point surveys (Berrow & Veale, 2024).

Visual surveys help determine the presence of animals at specific dates and times, while acoustic monitoring offers insights into their presence and behaviour over the period the acoustic monitoring equipment is deployed. Through continued acoustic monitoring, long-term impacts of activities on marine species can be observed. This study reveals that both seal species detected exhibit diverse behaviours and site usage patterns.

Grey Seal produced a wide range of vocalisations throughout the SoundTrap deployment period, with some call types (Rupe D and Type 4C) recorded for the first time in this study. Although still under investigation, certain calls have been associated with specific behaviours, including communication, territorial defence, and mating (guttural rupe; Pérez Tadeo *et al.*, 2023), female–male social interactions (rupes and moans; Asselin *et al*., 1993; McCulloch, 2000; Prawirasasra *et al.,* 2021), and sexual and dominance displays (trrot; Schneider, 1974).

A higher vocalisation rate was recorded during the day, in June, and ebb tides, despite elevated ambient noise levels (O'Brien *et al.,* 2024). Higher vocalisation rates have been observed towards the end of pre-breeding and during breeding seasons (long-term studies, Prawirasasra *et al*., 2021; Pozo Galvan *et al*., 2024) while lower vocalisation rates have also been observed towards the end of pre-breeding and during breeding seasons in the Blaskets (short-term study, Pérez Tadeo, 2022). The vocalisation rate may have been higher than recorded, but masking effects likely obscured detection, especially in May and June, both of which were generally very noisy months. Note that the high levels of ambient noise may have masked the low-frequency calls produced by these pinniped species.

Recordings captured both adult Harbour Seal and pups during May and June, coinciding with the species' breeding season. Despite the low number of calls, Harbour Seal exhibited a range of vocal behaviours, including roars, grunts, creaks, and growls. Notably, bubbly growls were recorded for the first time in adults in Ireland—previously documented only in male adult Harbour Seal in California (Hanggi & Schusterman, 1994). Additionally, Harbour Seal pups were recorded in two distinct contexts: emitting typical mother-attraction calls and, in an aggressive context, producing aggressive vocalisations (Khan *et al.,* 2006).

Harbour Seal are known to forage closer to their haul-out sites during the breeding season. Cronin *et al.* (2010) used satellite telemetry to track Harbour Seal across various locations in southwest Ireland, including sites in County Wexford. Their research revealed that during this critical period, Harbour Seal in Wexford primarily foraged within 20 to 50 km of their haul-out sites, particularly in Wexford Harbour and around the Saltee Islands.

However, some individuals were recorded travelling up to 100 km when food was scarce. These seals targeted shallow coastal waters and estuaries for their foraging activities. Given that the Proposed Development is located approximately 9 km from the Slaney River Valley Special Area of Conservation (SAC) (Site Code 000781), where Harbour Seal is a qualifying species, it is considered likely that the detected individuals belong to this population.

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APPENDIX A FIELD (SPECIES-SPECIFIC) SURVEY MAPS

Harbour Porpoise – Year 1

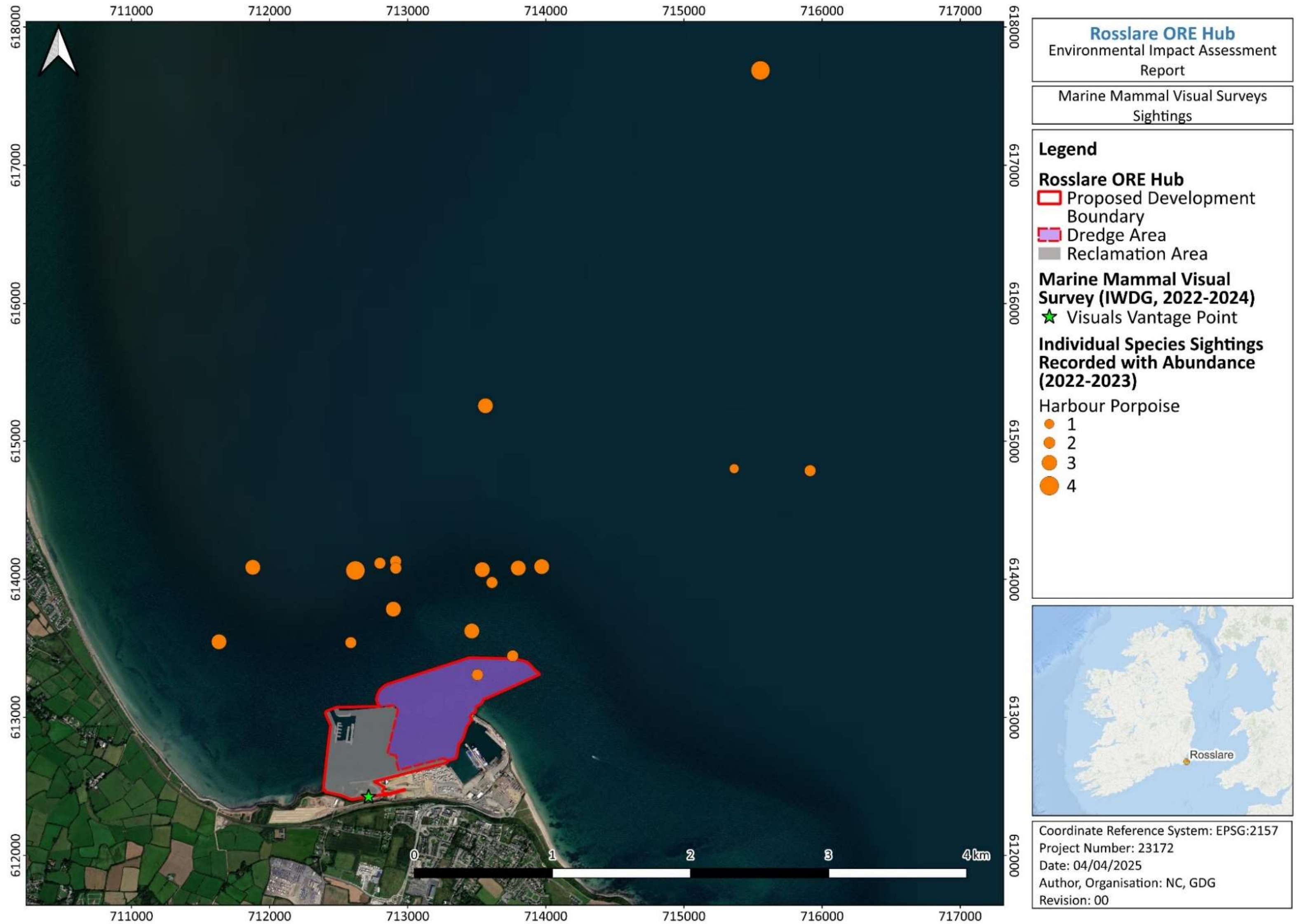


Figure A-13-47 Harbour Porpoise sightings during VP surveys from July 2022 to June 2023

Harbour Porpoise – Year 2

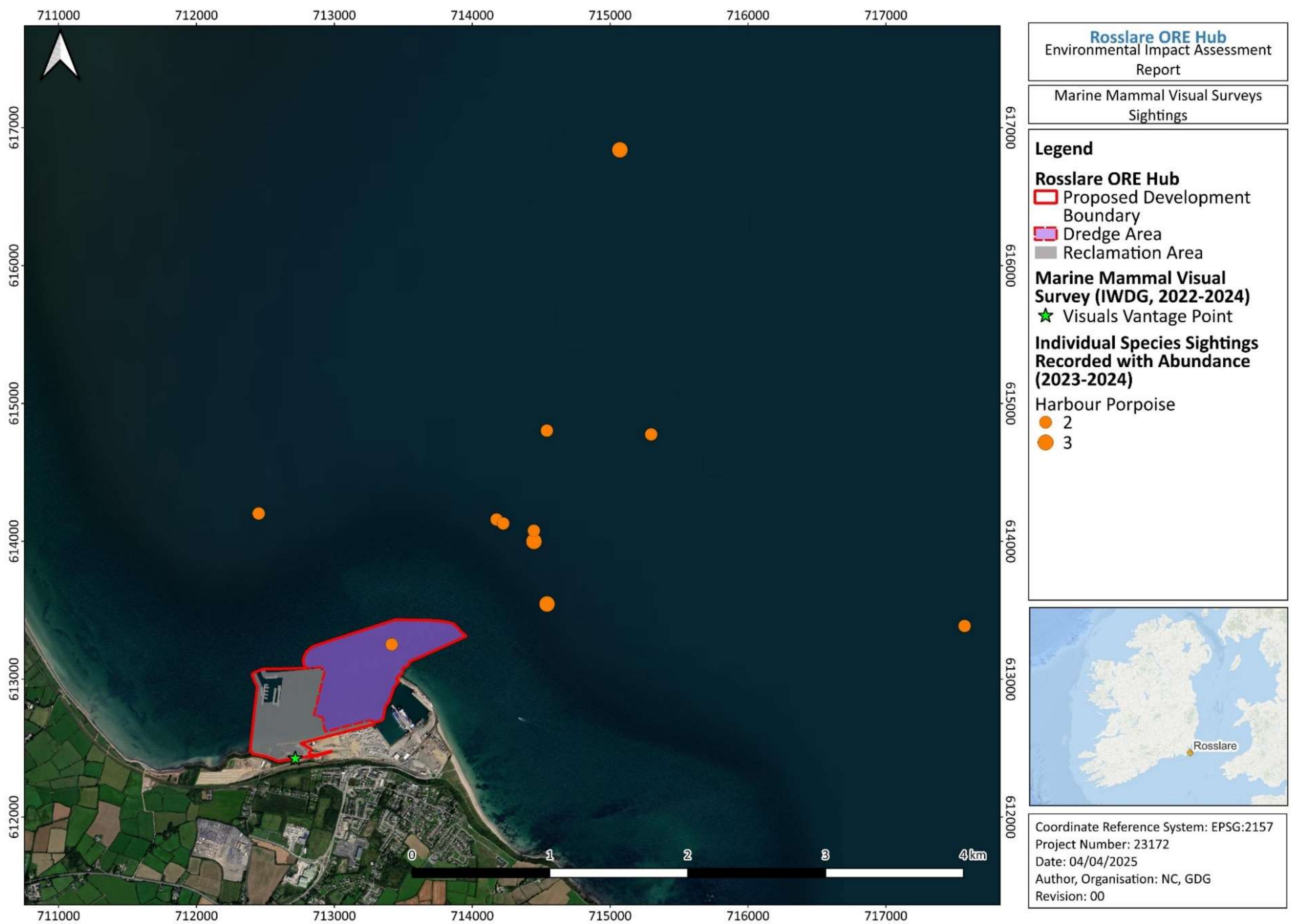


Figure A-2 Harbour Porpoise sightings during VP surveys from September 2023 to August 2024

Bottlenose Dolphin – Year 1

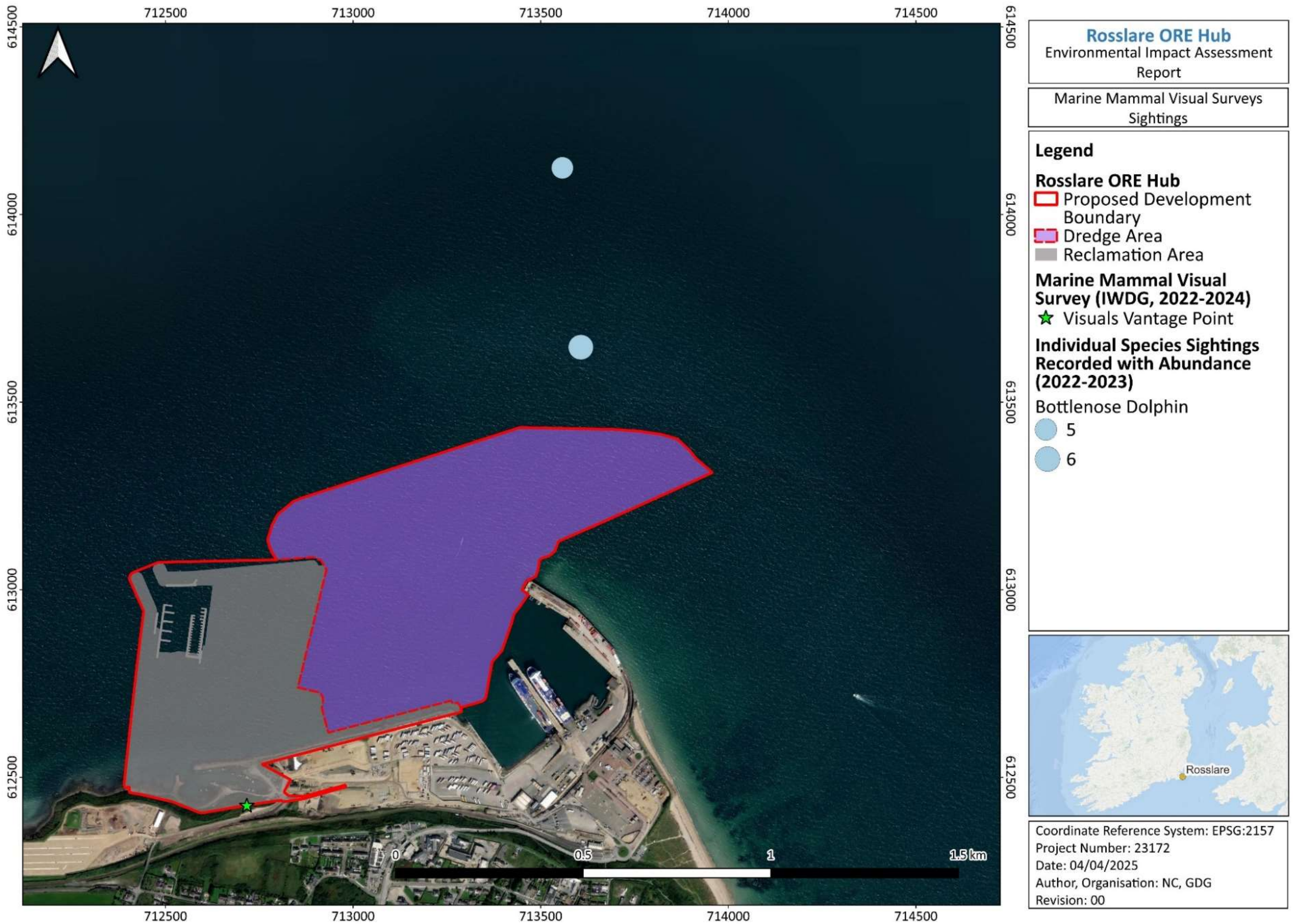


Figure A-3 Bottlenose Dolphin sightings during VP surveys from July 2022 to June 2023

Bottlenose Dolphin – Year 2

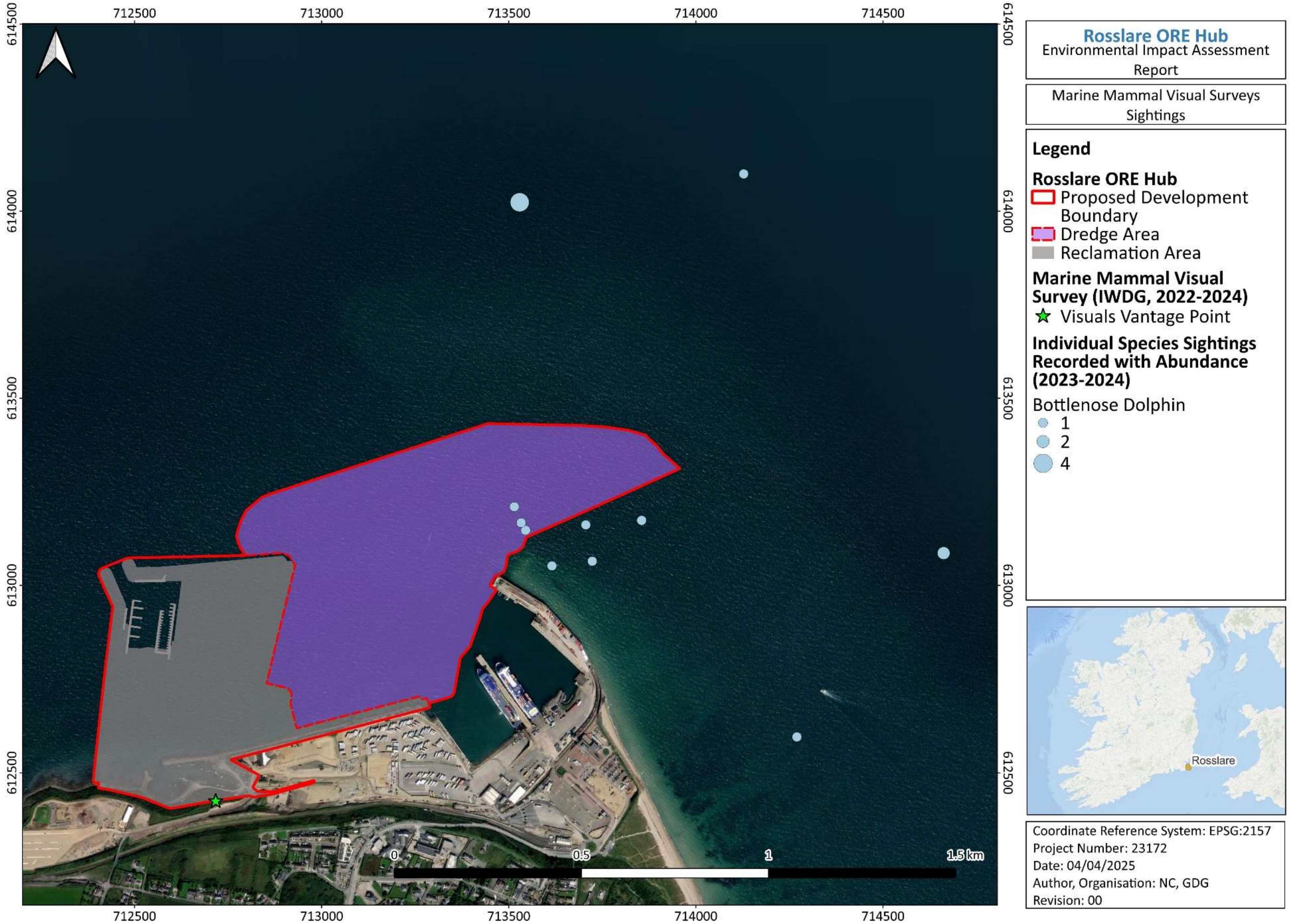


Figure A-13-48 Bottlenose Dolphin sightings during VP surveys from September 2023 to August 2024

Common Dolphin – Year 1

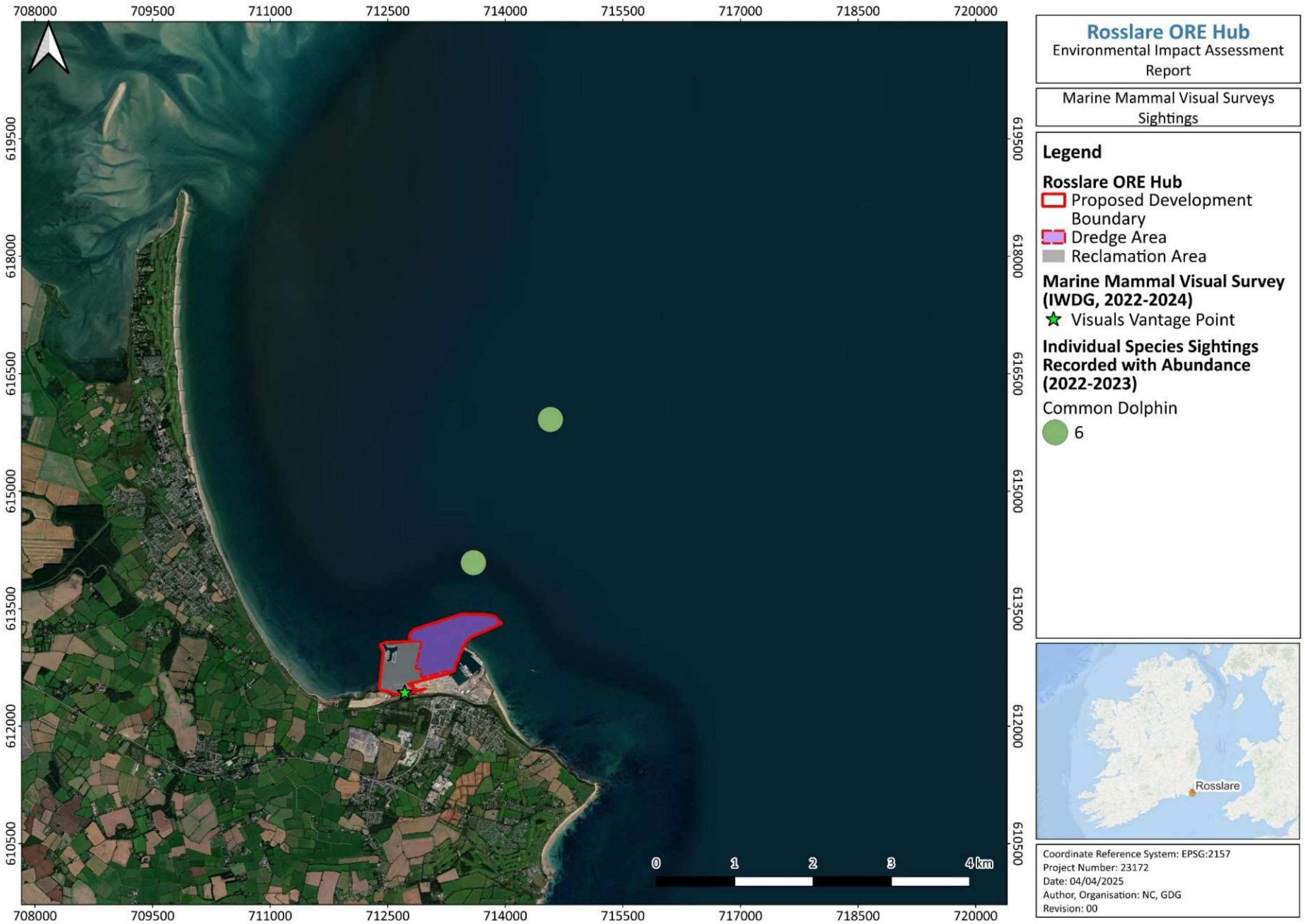


Figure A-5: Common Dolphin sightings during VP surveys from July 2022 to June 2023

Common Dolphin – Year 2

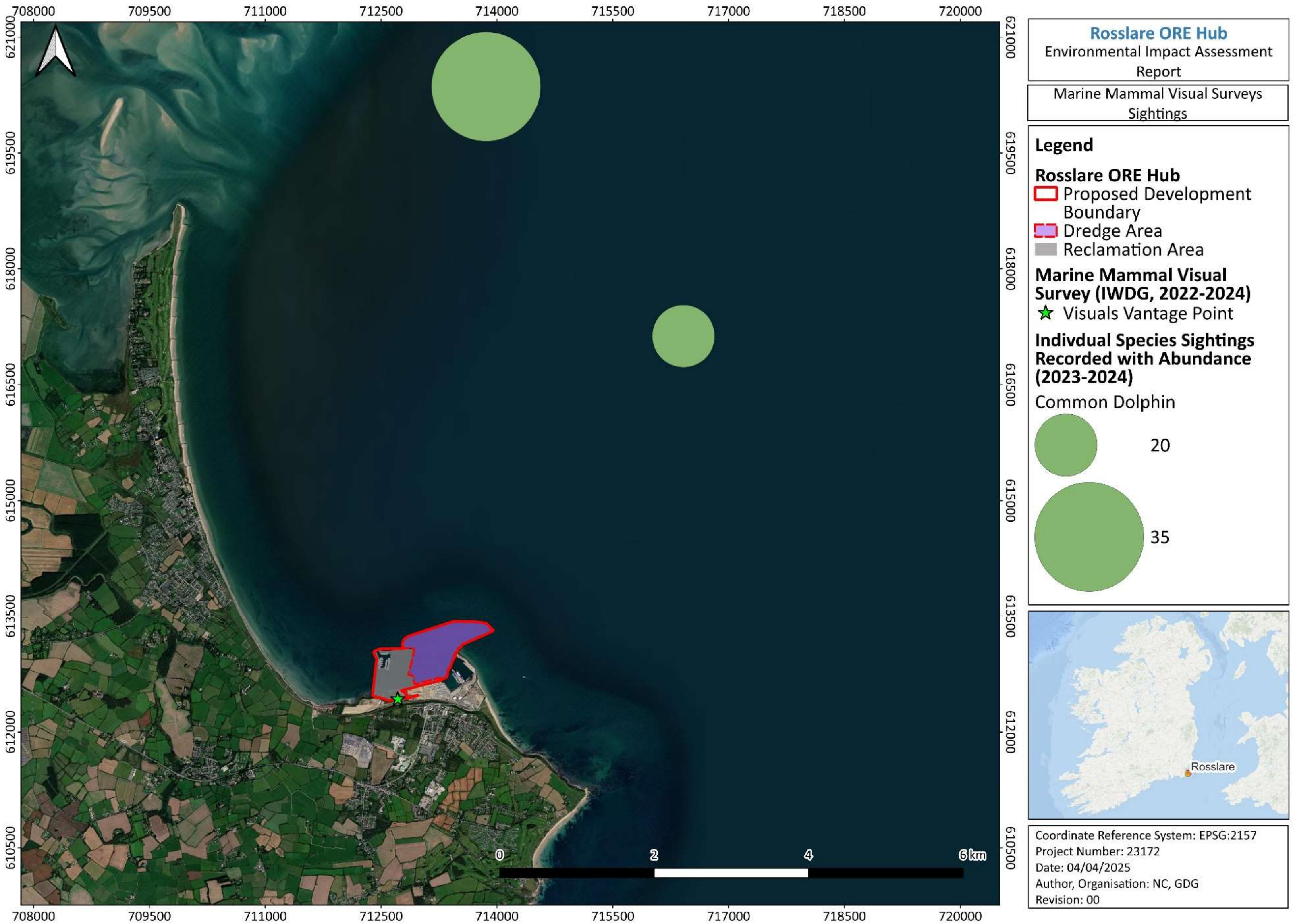


Figure A-6 Common Dolphin sightings during VP surveys from September 2023 to August 2024

Grey Seal – Year 1

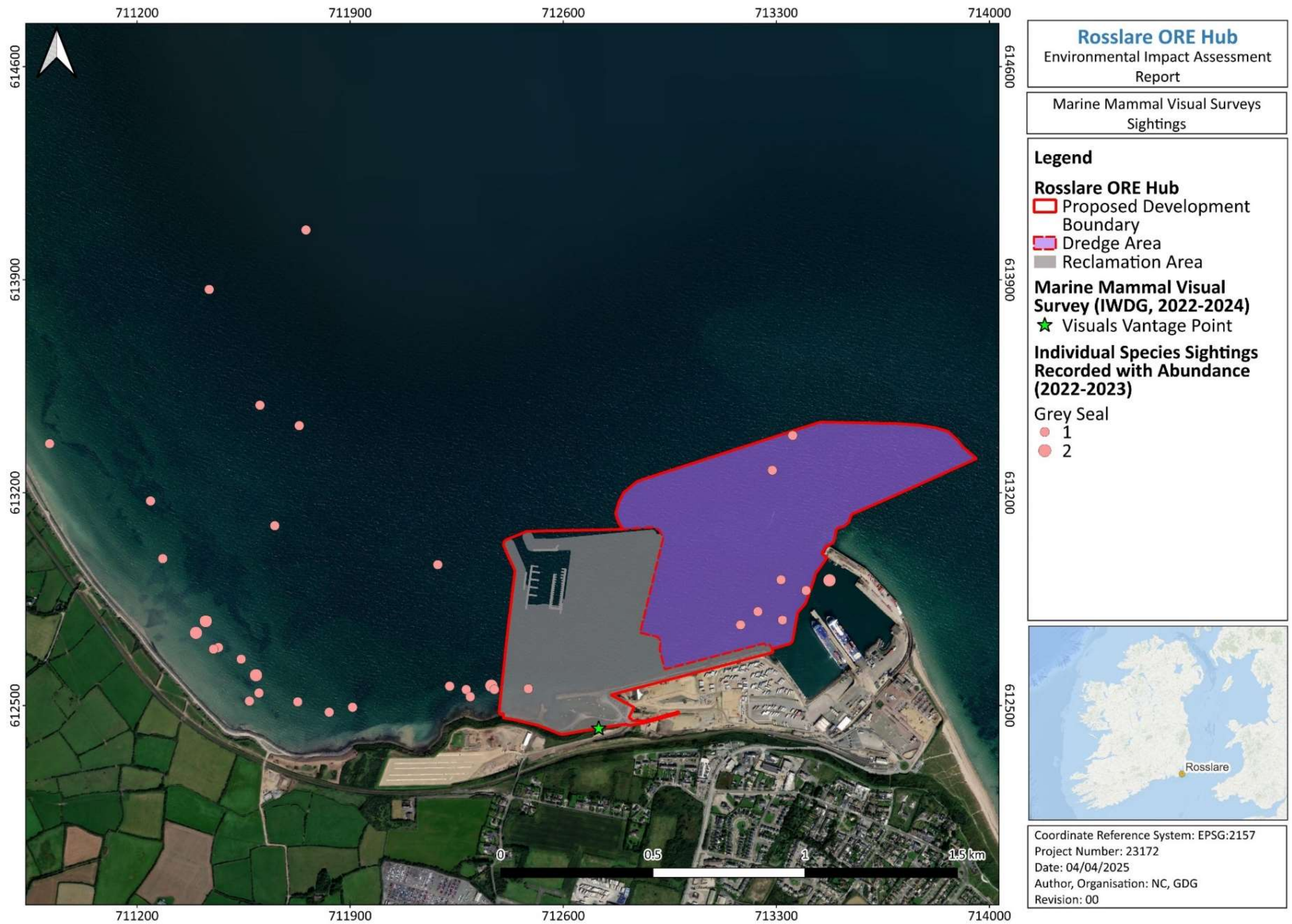


Figure A-7 Grey Seal sightings during VP surveys from July 2022 to June 2023

Grey Seal – Year 2

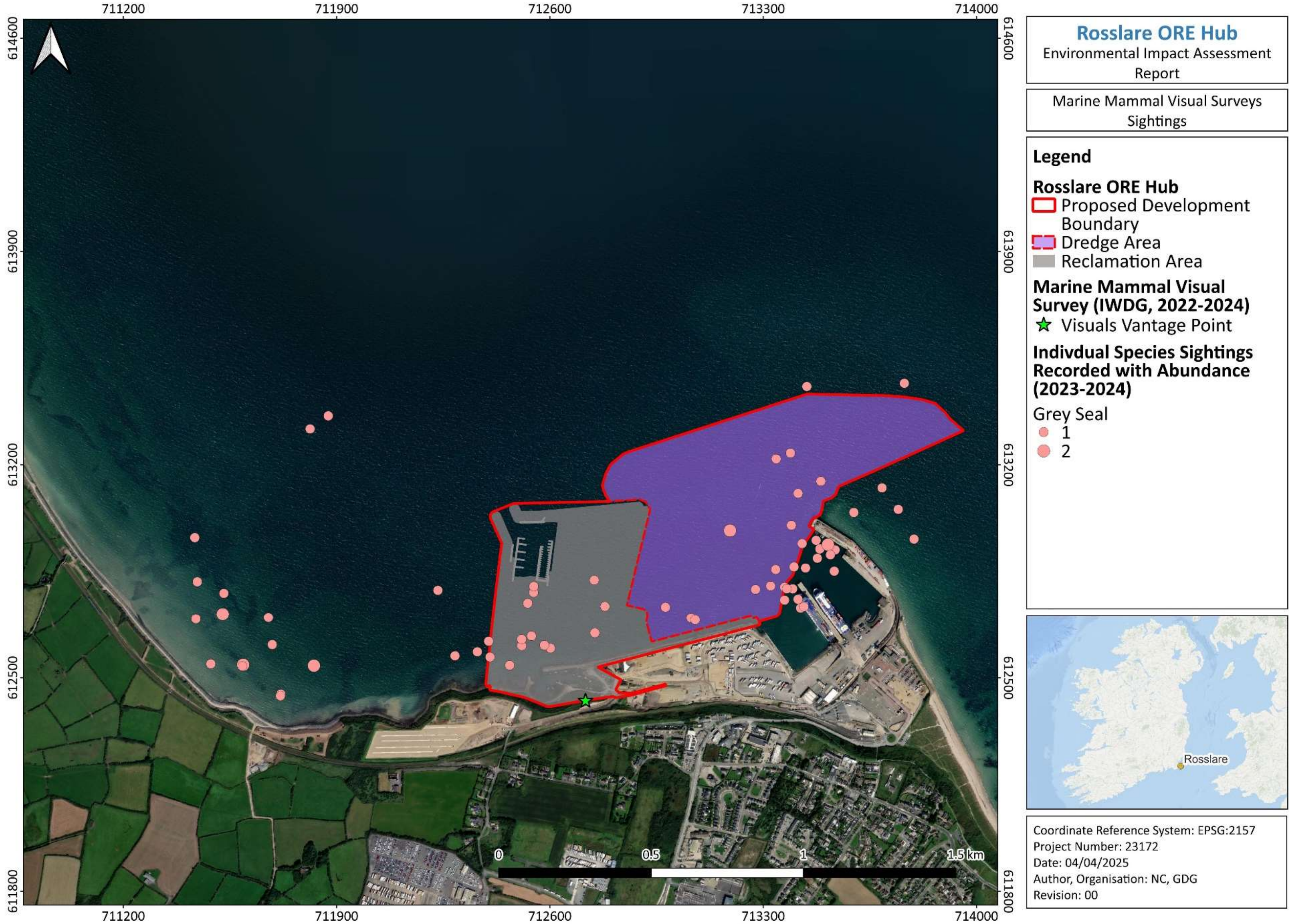


Figure A-8 Grey Seal sightings during VP surveys from September 2023 to August 2024

Harbour Seal – Year 2

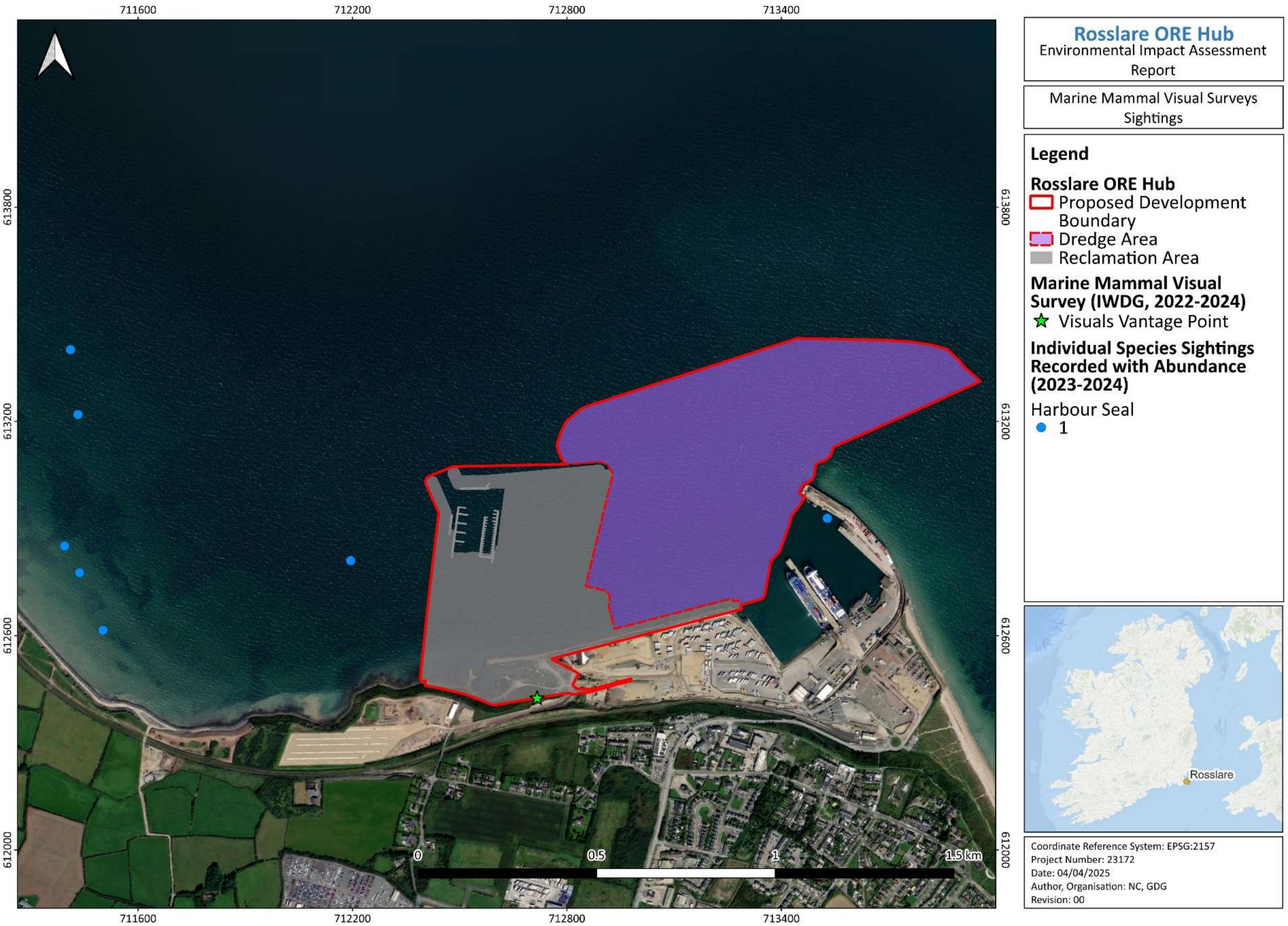


Figure A-9 Harbour Seal sightings during VP surveys from September 2023 to August 2024 (Note: no Harbour Seal sightings during 2022/2023 survey)

Risso's Dolphin – Year 1

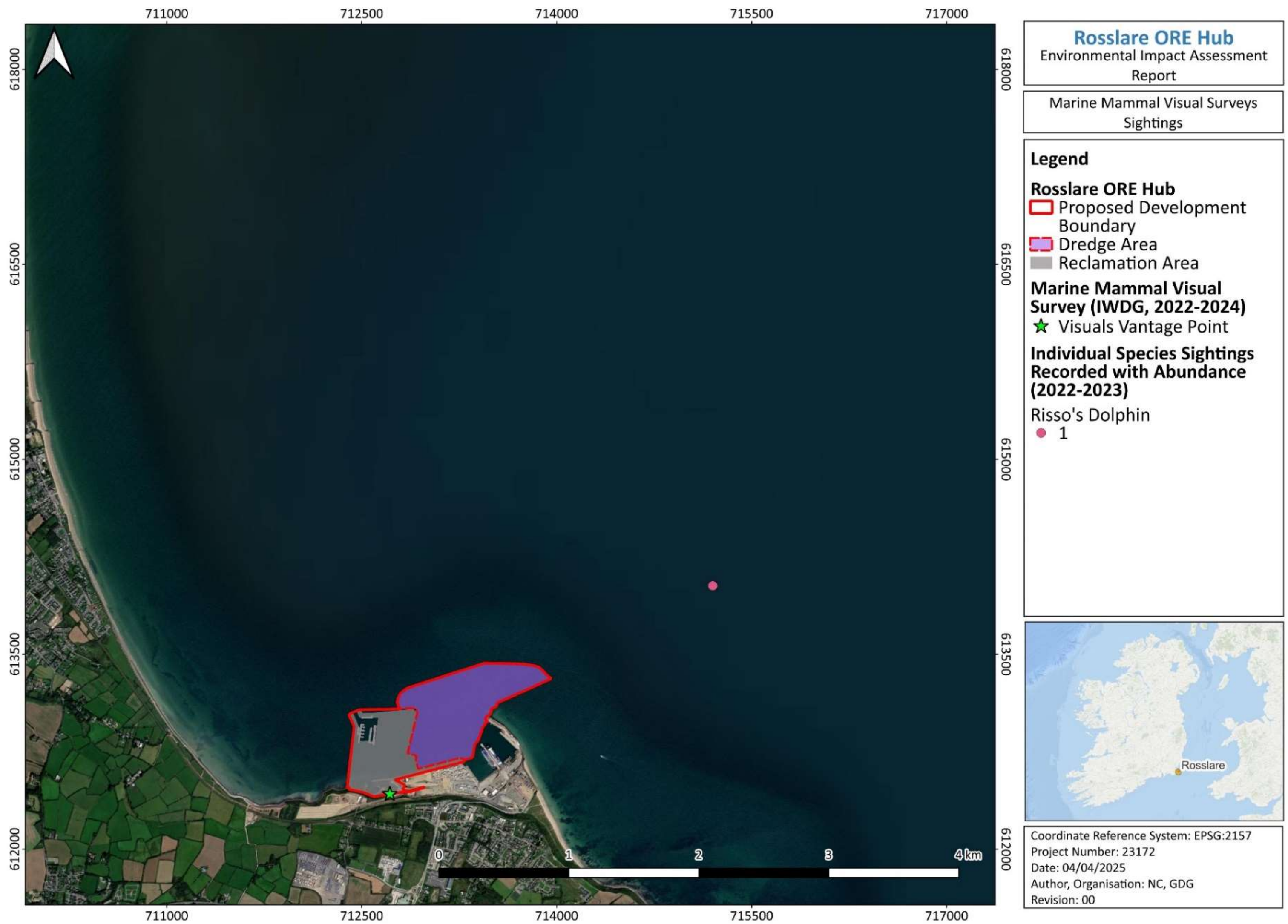


Figure A-10 Risso's Dolphin sighting during VP surveys from July 2022 to June 2023

Risso's Dolphin – Year 2

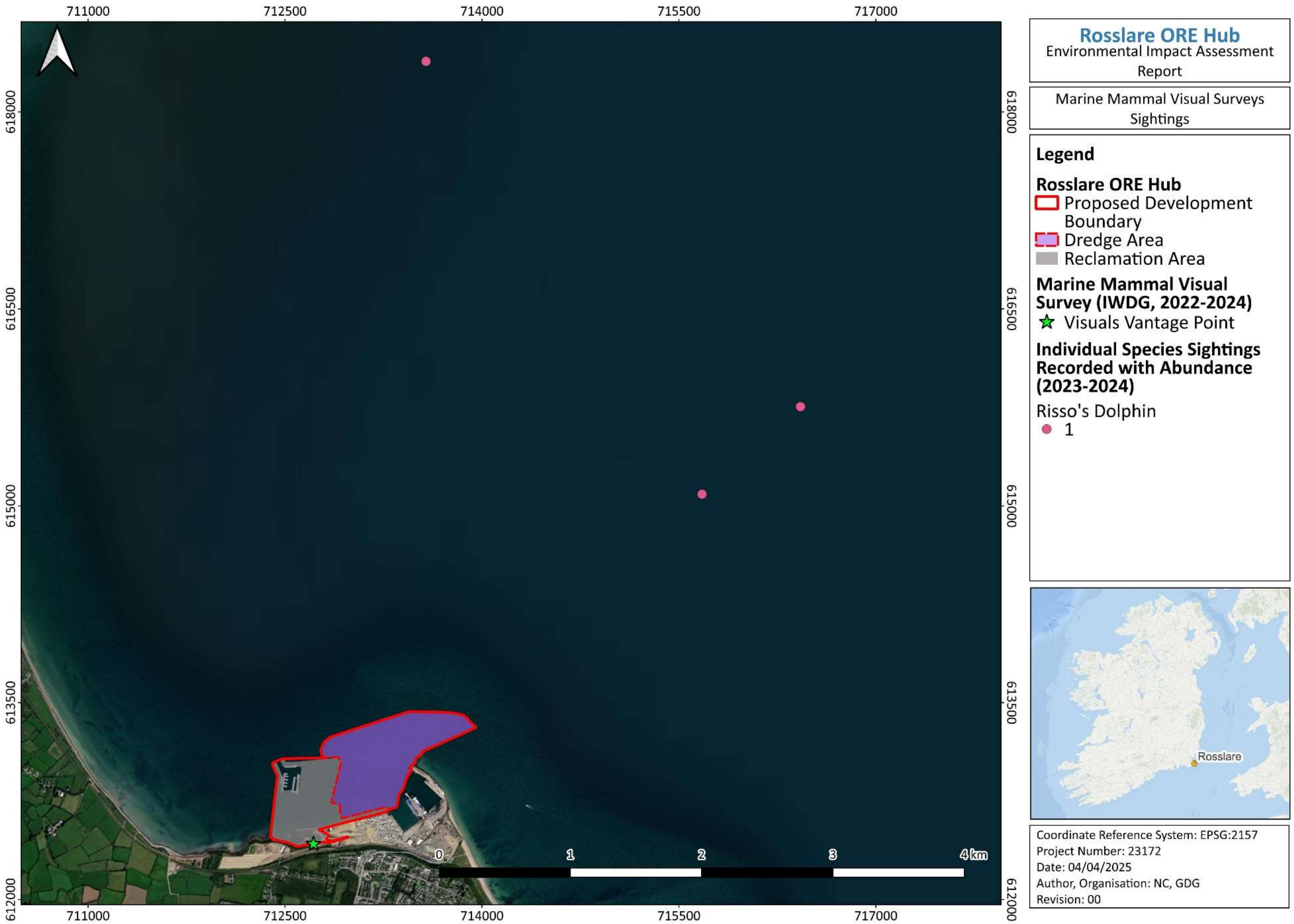


Figure A-11 Risso's Dolphin sightings during VP surveys from September 2023 to August 2024

Minke Whale – Year 1

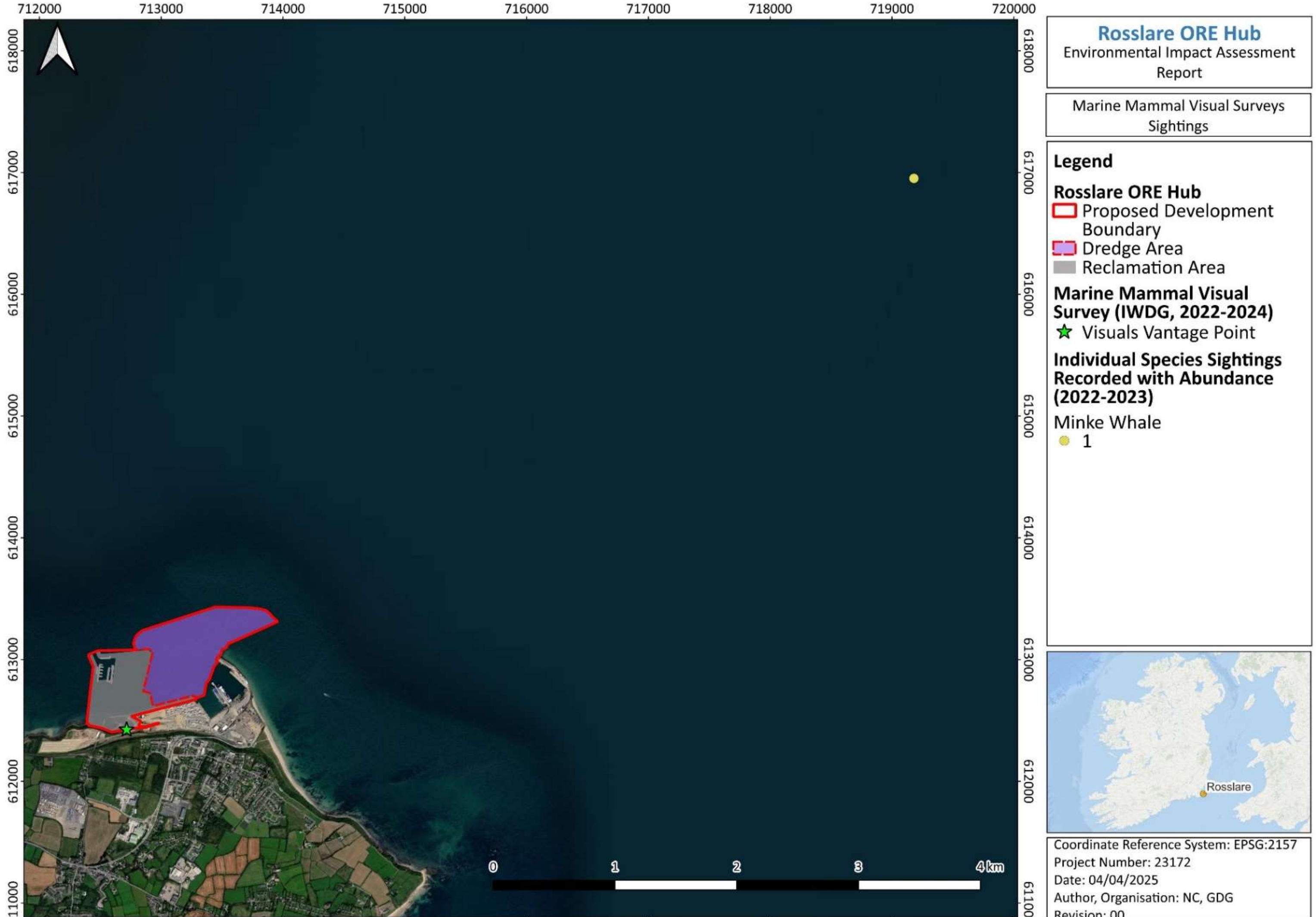


Figure A-12 Minke Whale sighting during VP surveys from September 2022 to August 2023

Minke Whale – Year 2

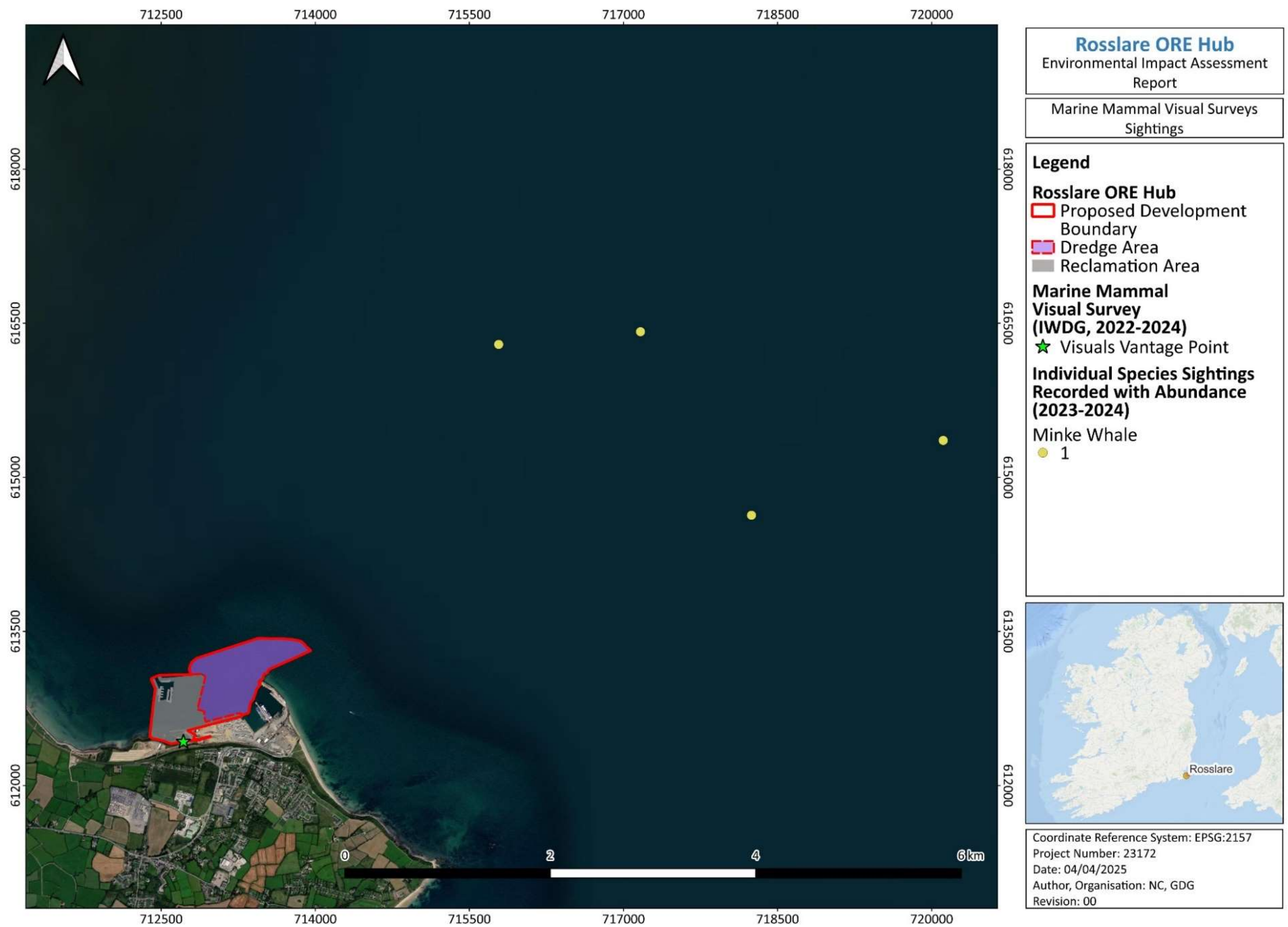


Figure A-13 Minke Whale sightings during VP surveys from September 2023 to August 2024

Sunfish - Year 1

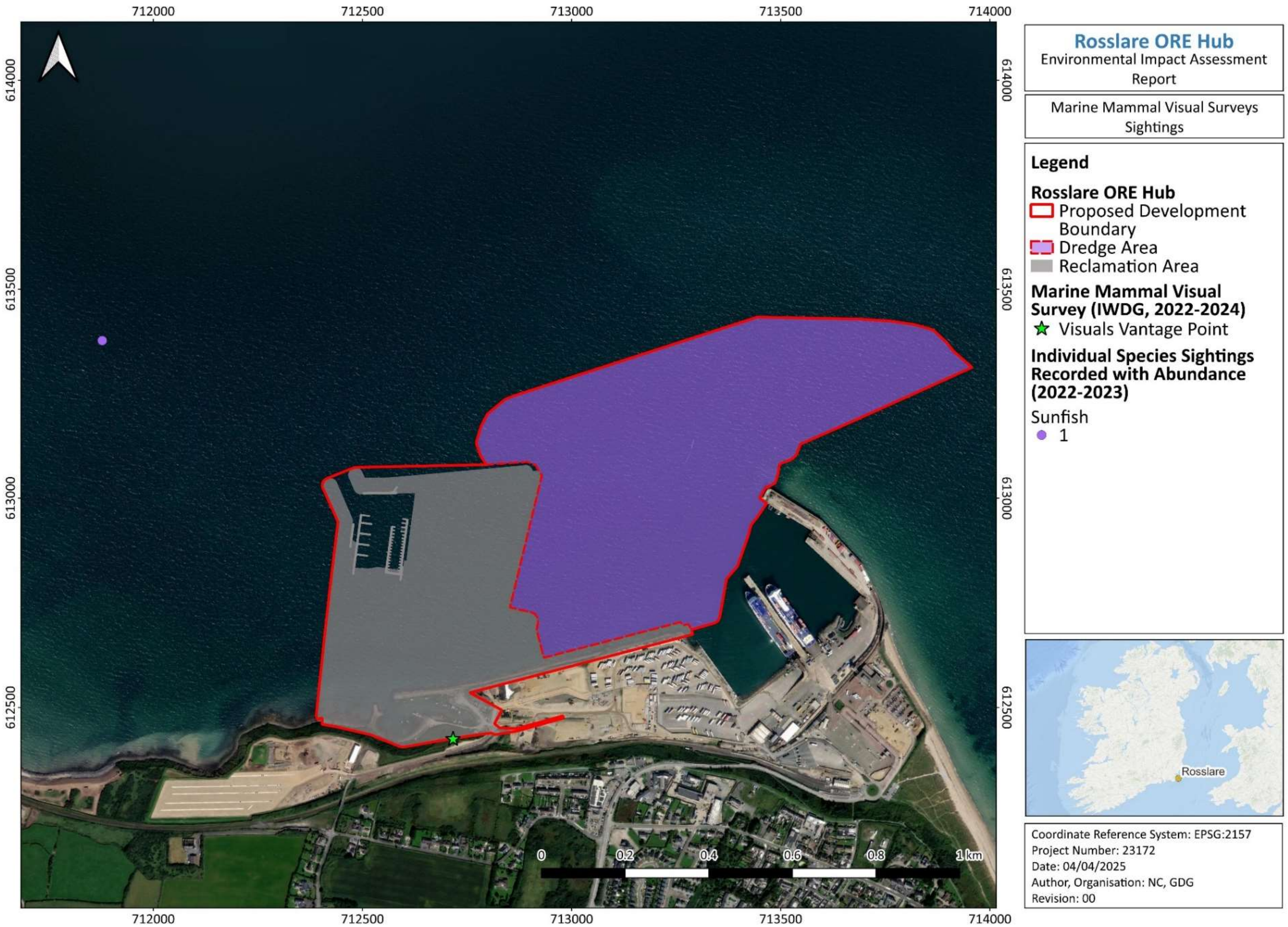
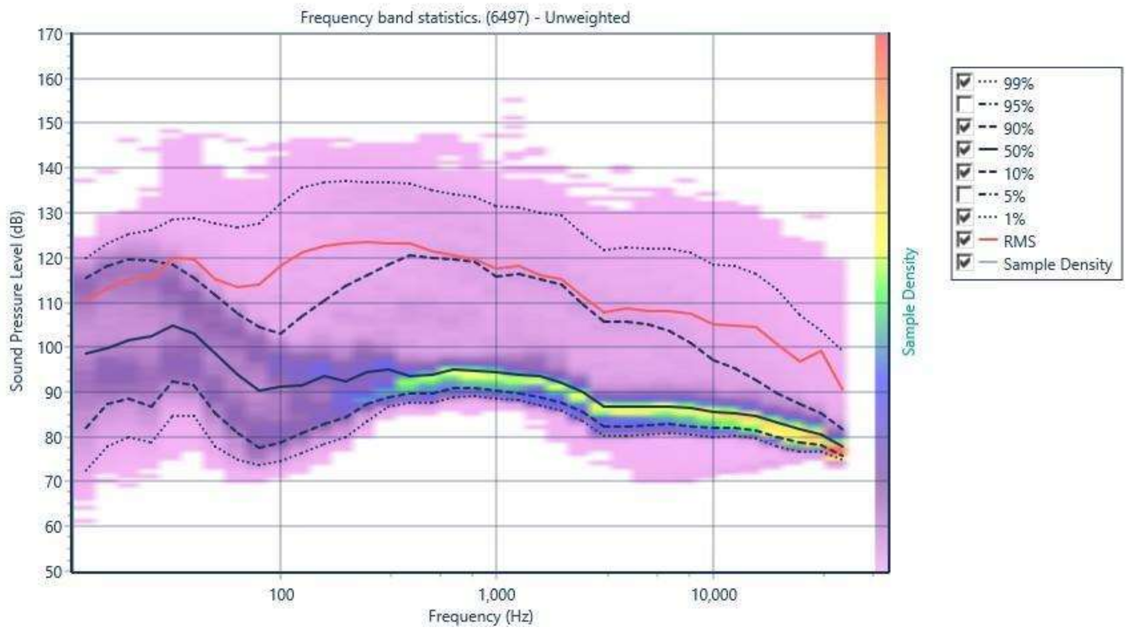


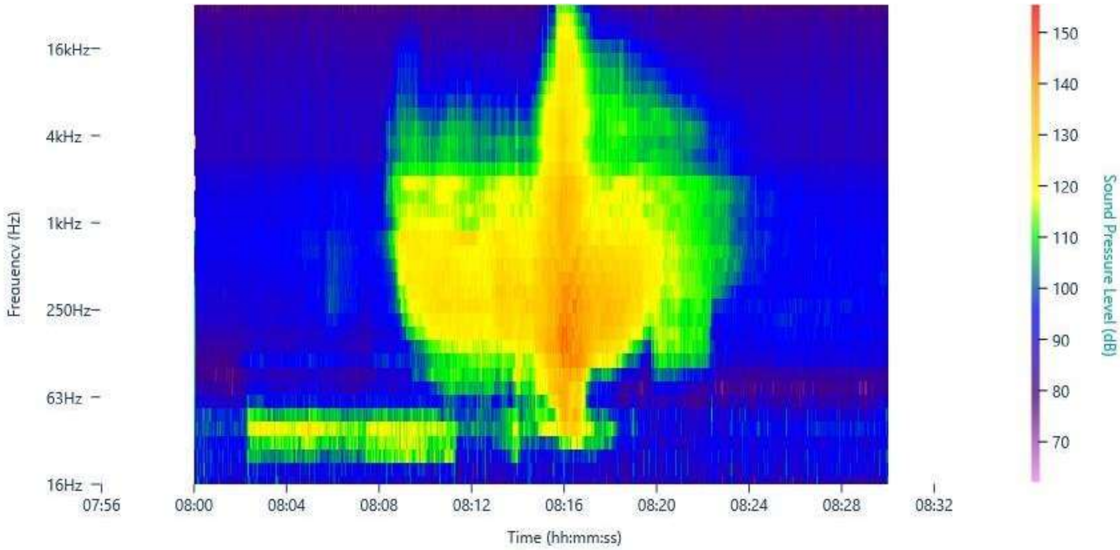
Figure A-14 Sunfish sighting during VP surveys from September 2022 to August 2023 (Note: There were no Sunfish sightings during the 2023/2024 survey)

APPENDIX B FREQUENCY BAND STATISTICS PLOTS AND SPECTROGRAMS GENERATED FROM ACOUSTIC FILES RECORDED ON THE DAYS WITH THE HIGHEST DAILY AVERAGE SPLS

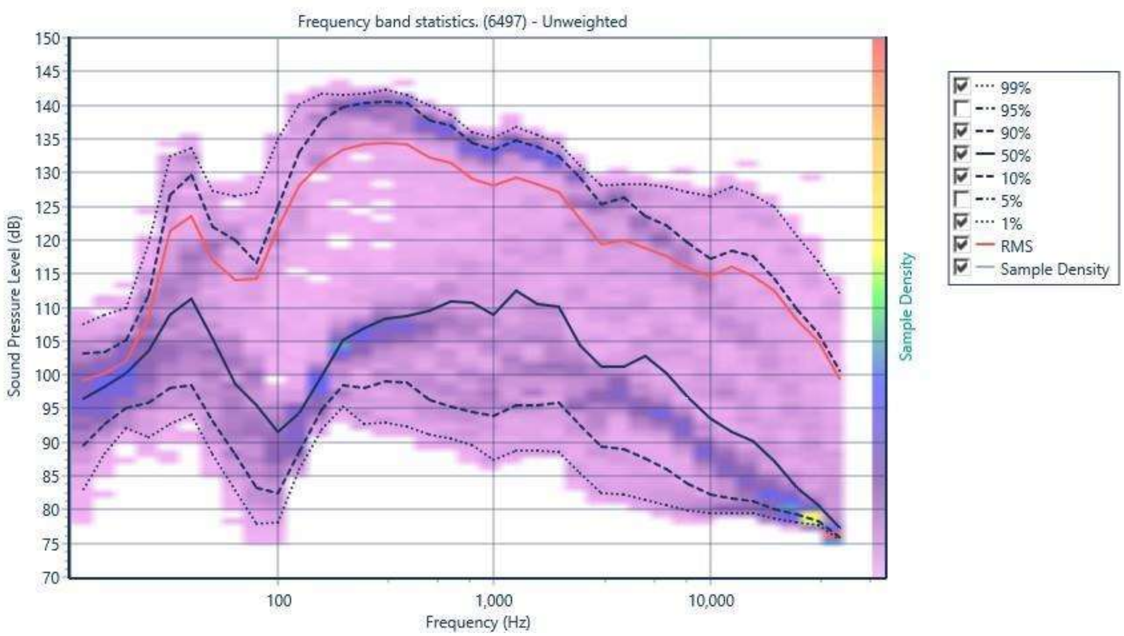
B.1 FREQUENCY BAND STATISTICS CORRESPONDING TO THE AUDIO FILES RECORDED ON THE 27/04/2024.



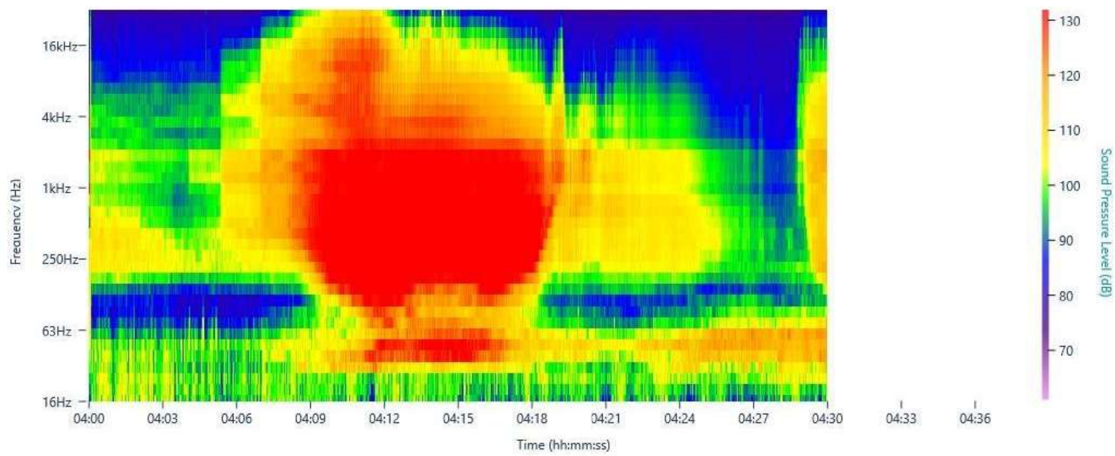
B.2 SPECTROGRAM CORRESPONDING TO THE AUDIO FILES RECORDED ON THE 27/04/2024 AT 8:00.



B.3 FREQUENCY BAND STATISTICS CORRESPONDING TO THE AUDIO FILES RECORDED ON 06/05/2024.

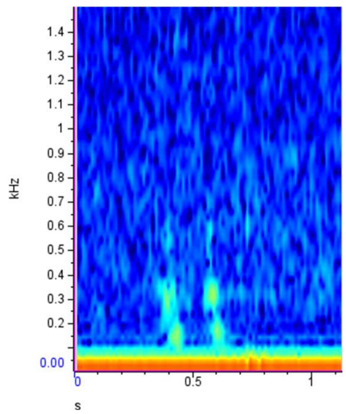


B.4 SPECTROGRAM CORRESPONDING TO THE AUDIO FILES RECORDED ON 06/05/2024.

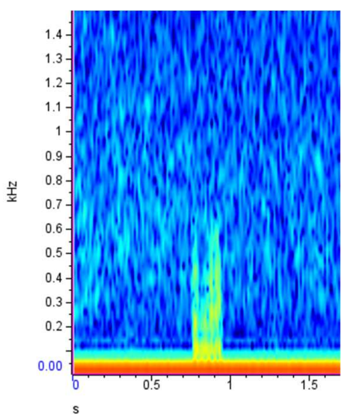

16kHz
4kHz
1kHz
250Hz
63Hz
16Hz
Frequency (Hz)
04:00
04:03
04:06
04:09
04:12
04:15
04:18
04:21
04:24
04:27
04:30
04:33
04:36
Time (hh:mm:ss)
130
120
110
100
90
80
70
Sound Pressure Level (dB)

APPENDIX C SEAL VOCALISATIONS – SPECTROGRAMS AND STATISTICS

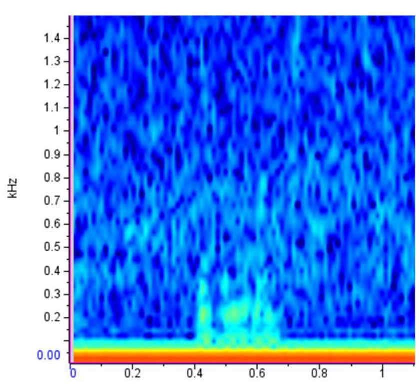
C.1 GREY SEAL VOCALISATION TYPES - SPECTROGRAMS SHOW THE FREQUENCY (KHZ) VERSUS TIME (S) PER VOCALISATION TYPE



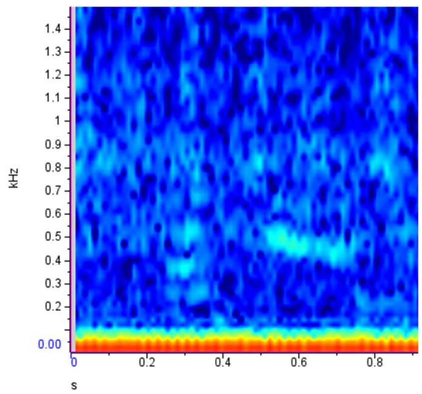
C-1.1 Guttural rupe



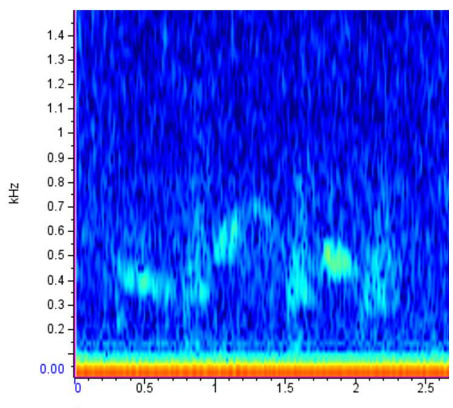
C-1.2 Rupe A



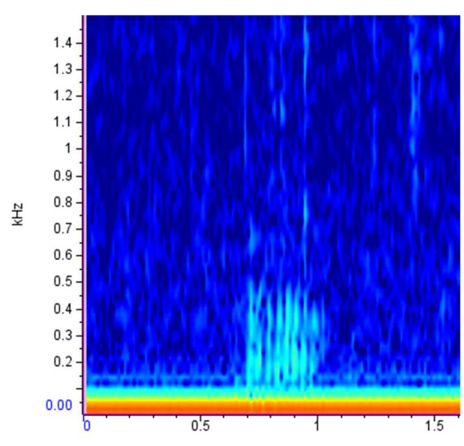
C-1.3 Rupe B



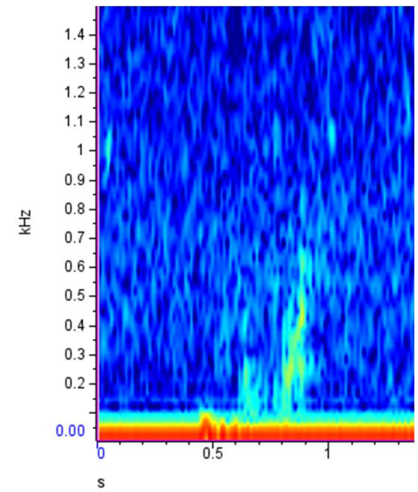
C-1.4 Rupe C



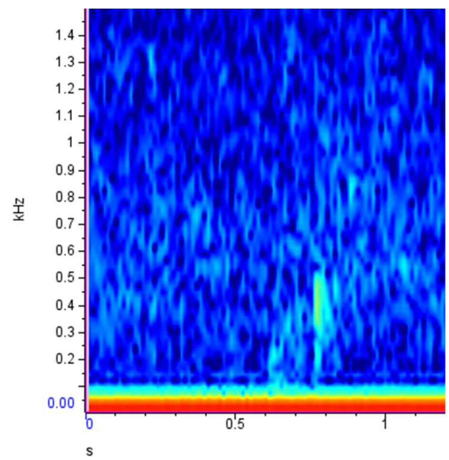
C-1.5 Rupe D (two calls are shown).



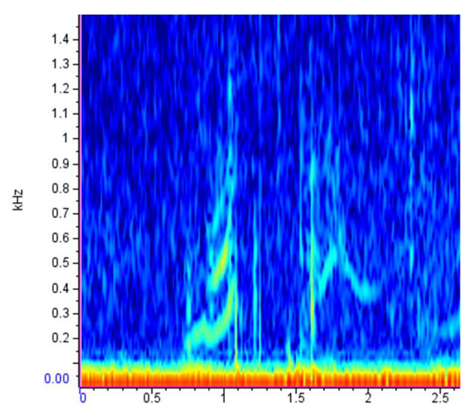
C-1.6 Trrot



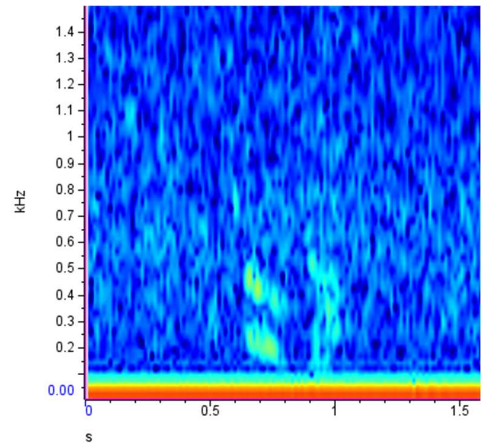
C-1.7 Type 4A



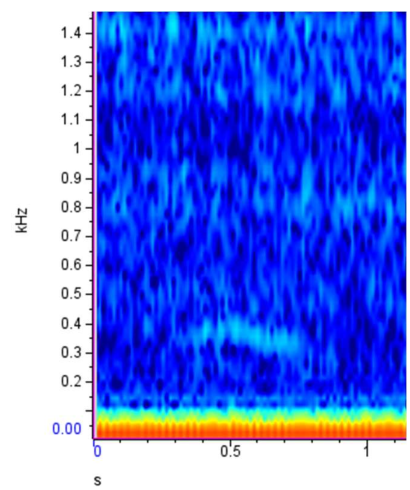
C-1.8 Type 4B



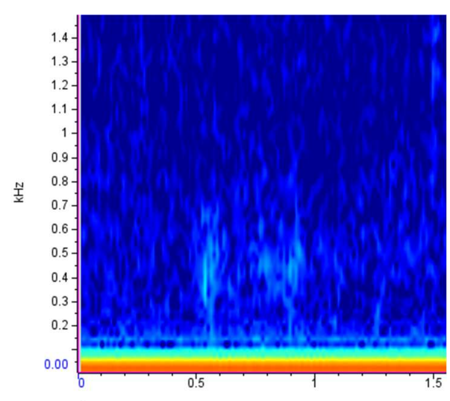
C-1.9 Type 4C



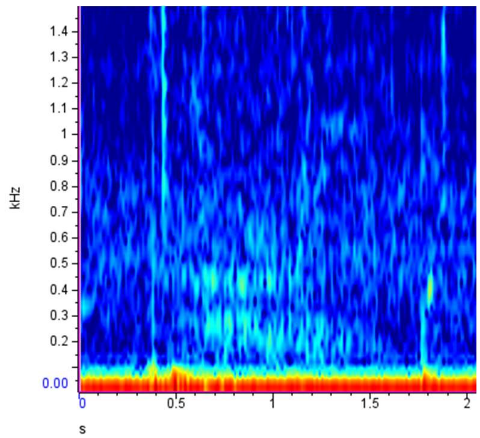
C-1.10 Type 5



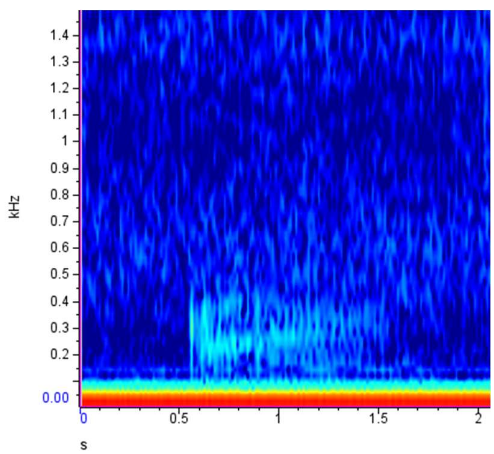
C-1.11 Moan



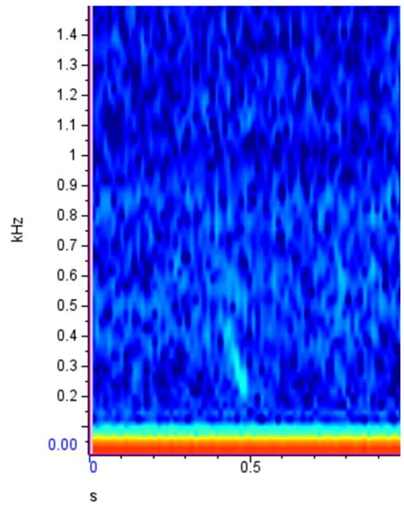
C-1.12 Type 7



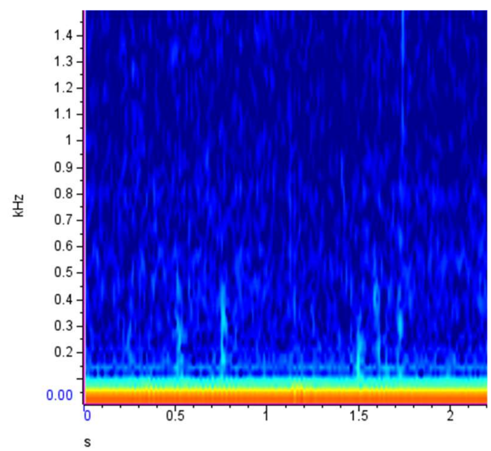
C-1.13 Growl A



C-1.14 Growl B

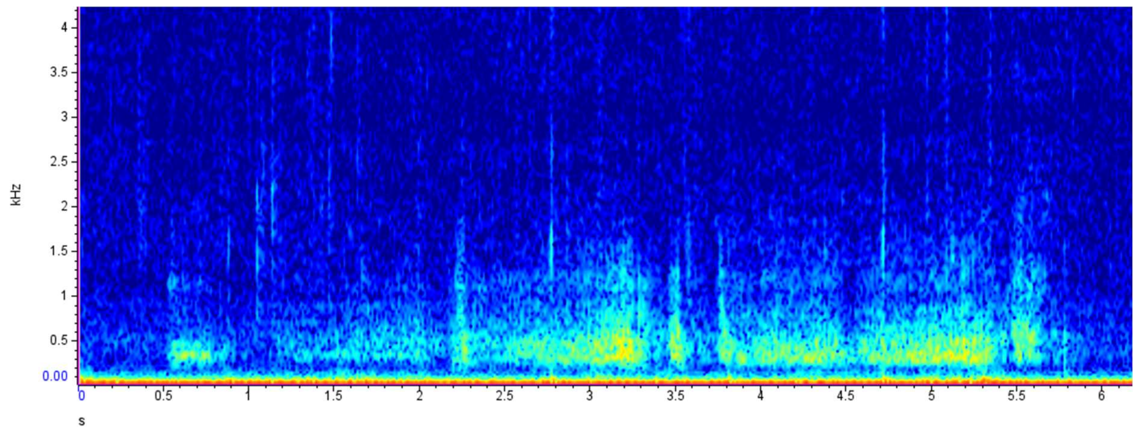


C-1.15 Cry

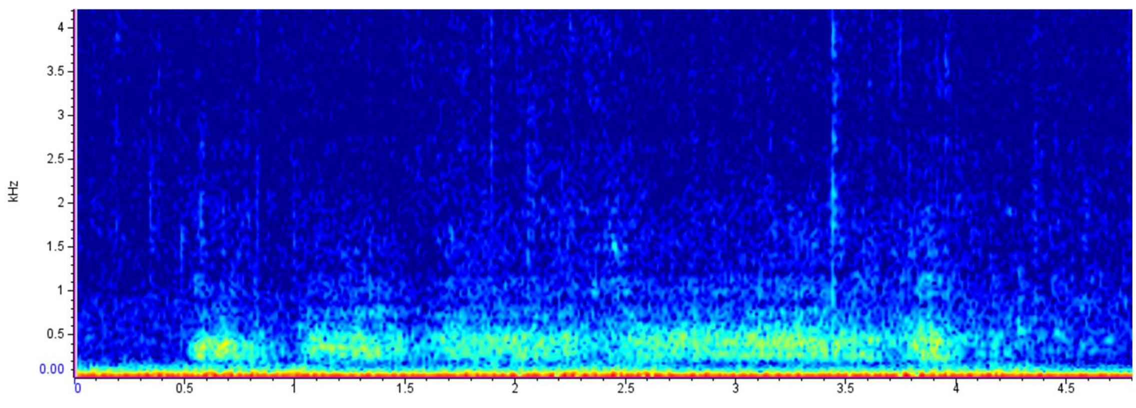


C-1.16 Pop

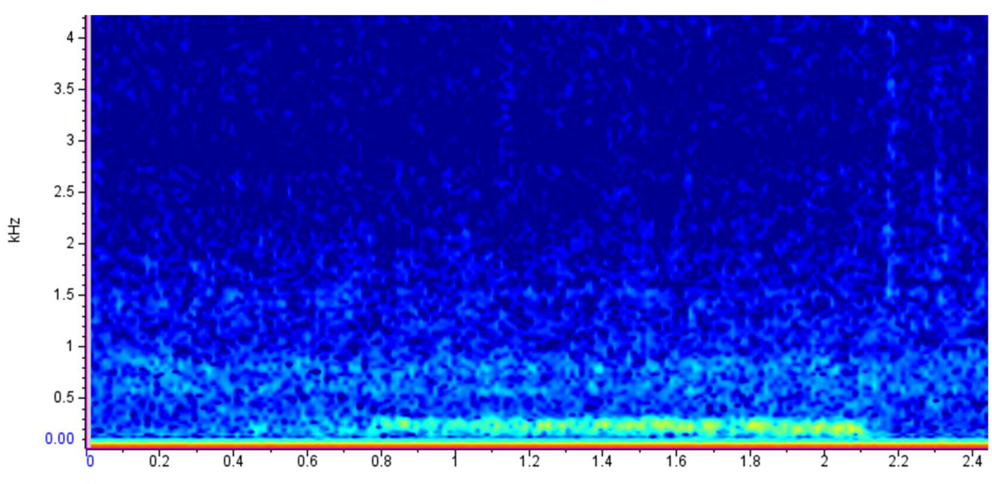
C.2 HARBOUR SEAL VOCALISATION TYPES - SPECTROGRAMS SHOW THE FREQUENCY (KHZ) VERSUS TIME (S) PER VOCALISATION TYPE



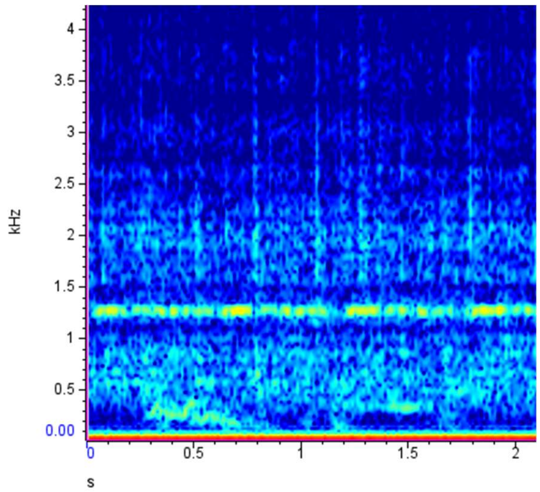
C-2.1 Roar



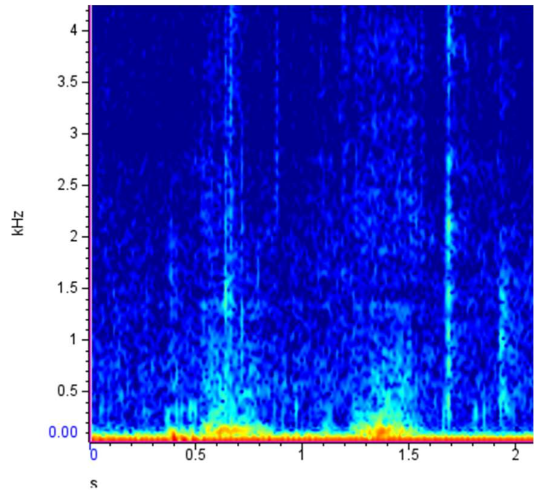
C-2.2 Growl



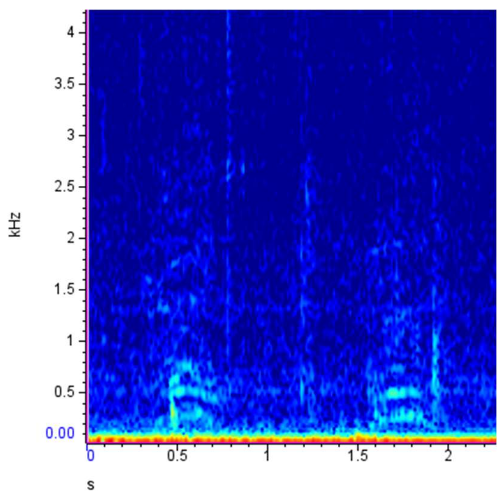
C-2.3 Bubbly Growl



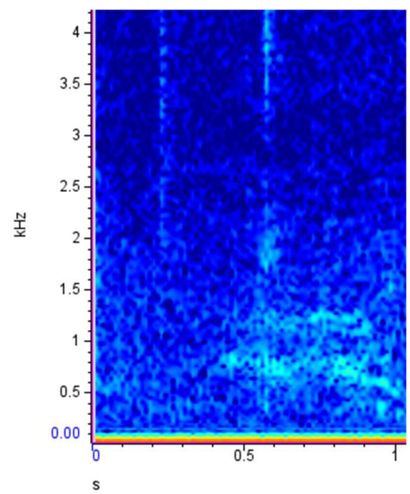
C-2.4 Creak



C-2.5 Grunt (two calls are shown)



C-2.6 Pup - Typical call



C-2.7 Pup - Aggressive

C.3 QUANTITATIVE DESCRIPTION OF CALLS

Table C-3.1 Quantitative description (mean ± SD) of each grey seal call (n = 6720). Proportion of vocalisations (N) per type is also presented.

Vocalisation Type	Low Frequency (Hz)	High Frequency (Hz)	Duration (s)	Frequency Range (Hz)	Peak Frequency (Hz)	Average Power Density (dB FS/Hz)	N (%)
Guttural rupe	118.75±53.56	637.87±233.45	0.28±0.09	519.12±245.65	276.17±112.17	-90.16±5.35	1.24
Rupe A	70.17±17.18	391.53±96.61	0.14±0.05	321.36±98.02	94.38±56.72	-92.54±4.14	67.14
Rupe B	66.09±15.48	393.59±88.57	0.25±0.07	327.5±92.11	85.7±46.07	-91.66±4.46	23.1
Rupe C	105.28±18.98	773.26±188.2	0.48±0.22	667.98±176.86	310.01±232.58	-98.16±1.94	0.33
Rupe D	100.06±27.98	820.82±304.96	0.5±0.13	720.76±303.05	268.63±142.76	-95.78±5.96	0.2
Trrot	95.66±46.16	521.27±592.27	0.32±0.41	425.61±576.90	172.07±154.10	-95.04±3.24	0.61
Type 4A	74.08±37.78	996.62±681.9	0.22±0.07	922.54±687.82	212.81±133.94	-89.65±4.68	0.37
Type 4B	83.9±34.5	586.2±95.72	0.22±0.06	502.3±114.8	276.56±189.97	-96.25±3.25	0.07
Type 4C	60.03	1308.06	1.39	1248.03	70.31	-90.33	0.02
Type 5	78.88±24.98	540.86±103.27	0.52±0.24	461.98±97.73	217.63±183.41	-92.14±5.41	0.1
Moan	203.79±35.57	350.2±66.81	0.92±0.42	146.41±59.31	269.56±58.88	-98.71±2.16	5.99
Type 7	113.74	764.61	0.63	650.87	351.56	-106.59	0.02

Vocalisation Type	Low Frequency (Hz)	High Frequency (Hz)	Duration (s)	Frequency Range (Hz)	Peak Frequency (Hz)	Average Power Density (dB FS/Hz)	N (%)
Growl A	59.35±3.5	1148.31±623.05	0.89±0.26	1088.96±619.55	70.31±0.00	-93.58±0.66	0.03
Growl B	85.41±20.79	497.49±125.4	0.53±0.25	412.09±126.83	161.6±105.94	-94.73±4.71	0.28
Cry	186.96±23.06	595.51±149.53	0.49±0.67	408.55±135.07	289.06±13.53	-97.35±3.22	0.04
Pop	130.38±50.14	720.57±225.16	0.33±0.28	590.19±216.85	285.79±138.71	-95.05±4.06	0.46

Table C-3.2 Quantitative description (mean ± SD) of each harbour seal call (n = 46). Proportion of vocalisations (N) per type is also presented.

Vocalisation Type	Low Frequency (Hz)	High Frequency (Hz)	Duration (s)	Frequency Range (Hz)	Peak Frequency (Hz)	Average Power Density (dB FS/Hz)	N (%)
Roar	95.21±44.05	4193.2±3732.25	1.35±1.02	4097.99±3745.83	281.25±210.84	-91.5±9.46	30.43
Growl	99.18±48.67	2297.92±780.36	3.58±2.89	2198.73±812.69	173.44±151.57	-96.28±3.48	21.74
Bubbly Growl	101.18±14.52	956.81±774.85	3.32±2.72	855.63±770.75	183.59±98.79	-93.33±5.46	13.04
Creak	80	1008	1.55	928	281.25	-92.49	2.17
Grunt	94.79±98.3	1341.23±541.71	0.27±0.1	1246.45±522.55	298.83±457.43	-87.21±6.83	8.7
Pup - Typical	287.63±307.63	3228.28±4623.61	0.39±0.18	2940.65±4424.17	666.67±769.35	-102.32±3.9	19.57
Pup - Aggressive	283.9±182.98	1796.09±640.52	0.61±0.02	1512.19±823.5	832.03±49.72	-96.63±5.88	4.35

C.4 PAIRWISE WILCOXON RANK-SUM TEST RESULTS FOR GREY SEAL VOCALISATION RATES ACROSS TIDAL STATES

Table C-4.3 Wilcoxon Rank-Sum Test Results for Vocalisation Rates Across Tidal States.

Comparison	Test Statistic	p-value	Significance level
Ebb vs. Flood	61058	2.81×10^{-11}	****
Ebb vs. High	5269335	2×10^{-211}	****
Ebb vs. Low	2730854	1.42×10^{-77}	****
Flood vs. High	633	3.69×10^{-11}	****
Flood vs. Low	1012	6.07×10^{-10}	****
High vs. Low	954228	3.2×10^{-2}	*

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EIAR Technical Appendices

Technical Appendix 13

Marine Mammals

Report 2:

Underwater Noise Modelling

venterra | GDG GAVIN & DOHERTY GEOSOLUTIONS

NICHOLAS O'DWYER an RSK company

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

13 UNDERWATER NOISE MODELLING

13.1 INTRODUCTION

This Technical Report forms **Report 2** of **Technical Appendix 13: Marine Mammals** and has been prepared to accompany **Volume 1: Chapter 13: Marine Mammals** of the Rosslare Europort Development (hereafter the 'Proposed Development') Environmental Impact Assessment Report (EIAR).

13.1.1 SCOPE OF REPORT

Gavin & Doherty Geosolutions (GDG) was commissioned by Iarnród Éireann to conduct underwater noise modelling to assess the potential impacts that underwater noise from activities associated with the Proposed Development (see Figure 13-1) may have on marine mammals and fish. Underwater noise generated during piling, dredging, and rock blasting activities has been identified as potentially having an adverse impact on marine mammals and fish. Further details of these activities can be found in Volume 1: Chapter 4: Project Description of the EIAR.

This Technical Report presents underwater noise modelling results to assess the potential impacts that piling, dredging, and rock blasting activities associated with the Proposed Development may have on marine mammals and fish. The remainder of this report is presented as follows:

- Section 1.3 introduces acoustic metrics and terminology that are used throughout the report
- Section 1.4 presents the modelling methodology that has been adopted for estimating received sound levels for the different activities considered in this assessment
- Section 1.5 discusses the impact assessment thresholds that have been used for assessing potential impacts to marine mammals and fish
- Section 1.6 presents the underwater noise modelling results and assessment of potential impacts to marine mammals and fish
- Conclusions are drawn in Section 1.7.

13.1.2 STATEMENT OF AUTHORITY

This report has been prepared by Andrew Millar (MEng, PhD Electronic and Electrical Engineering). Andrew is a Principal Acoustic Modeller at Venterra with over 10 years' experience in the offshore oil and gas and renewables industries. He routinely conducts underwater noise modelling, environmental impact assessments, and permit applications for a wide variety of UK and international projects for activities including seismic surveys, geophysical site surveys, piling, drilling, and explosives use. Andrew has developed Venterra's acoustic propagation modelling software for estimating the potential impacts of underwater noise on marine receptors.

This report has been reviewed by Joey O'Connor (BSc. (Hons) Marine Science, MSc. Engineering in the Coastal Environment). Joey is an Environmental Impact Assessment practitioner and Marine Scientist with coastal engineering expertise and extensive experience of offshore survey and Marine

Protected Area monitoring. Joey has had an overview role in this project as EIAR coordinator and Biodiversity Lead.

This report has been peer-reviewed by Dr. Laura Williamson from HiDef. Laura joined HiDef in August 2024 to lead Environmental Impact Assessments (EIAs) and Habitats Regulations Appraisals (HRAs) for marine mammals, underwater noise, and seabirds. She has a strong background in marine mammal ecology and risk mitigation, as well as survey design, data analysis, and reporting for the offshore wind sector. Prior to joining HiDef, Laura worked at Ocean Science Consulting Limited for six years, beginning in an R&D role before progressing to Head of Projects, where she was responsible for project management, business strategy, tendering and grant writing, quality assurance of reports and publications, as well as staff and student supervision and mentoring. During her MRes and PhD at the University of Aberdeen, Laura analysed data from echolocation-click detectors (C-PODs), as well as HiDef digital aerial video footage to investigate the distribution of harbour porpoise along the east coast of Scotland.

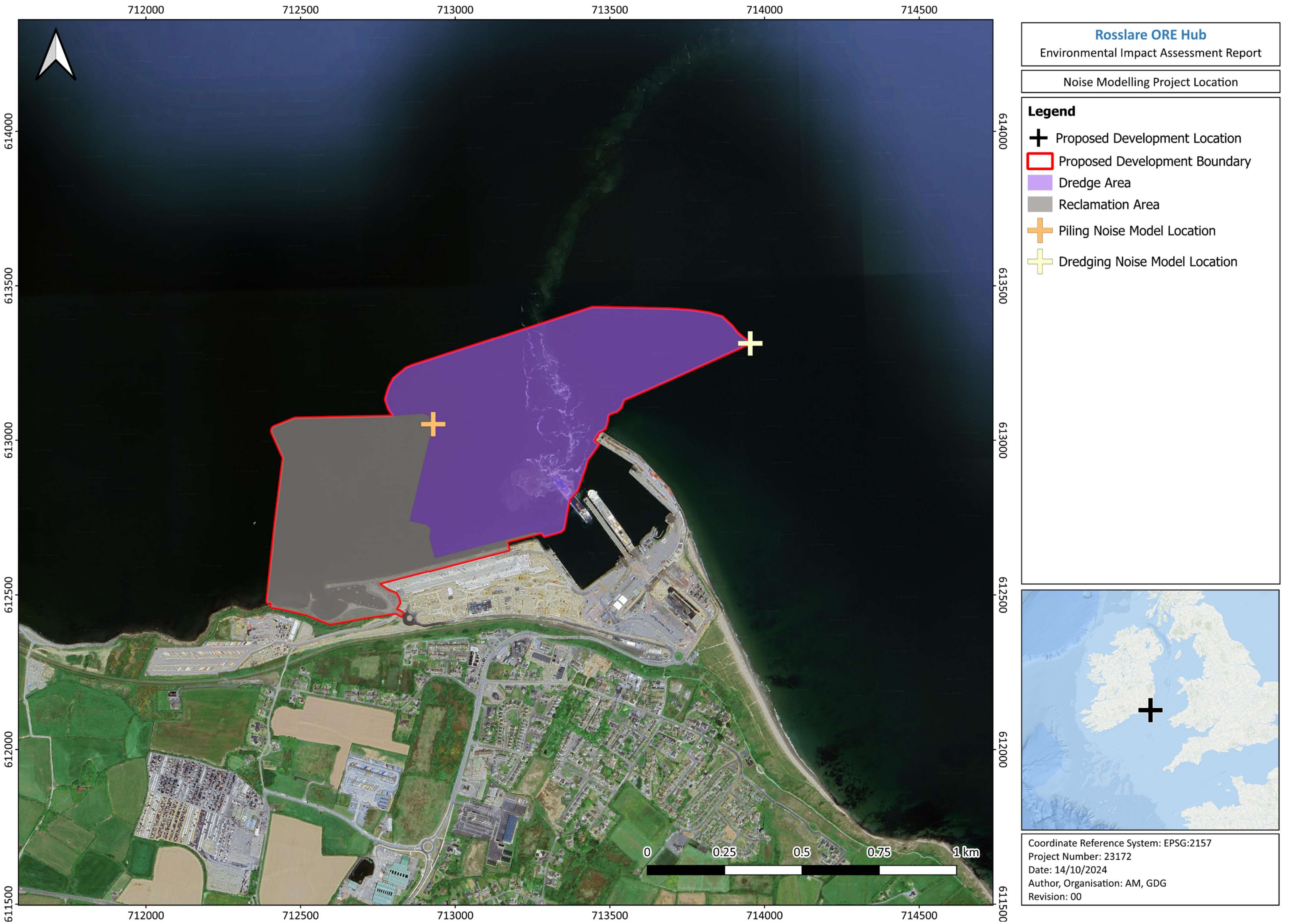

Figure 13-1: Proposed Development location

13.2 ACOUSTIC METRICS AND TERMINOLOGY

The metrics and terminology adopted in this report generally follow the International Standardisation Organisation (ISO) standard ISO 18405:2017 Underwater Acoustics – Terminology (ISO, 2017) as summarised in Ainslie *et al.* (2022).

13.2.1 SOUND AND NOISE

Sound is a mechanical wave that causes fluctuations in pressure and material displacement (particle motion) that propagates through a compressible medium (solid or fluid) by oscillation of the medium's particles (Erbe and Thomas, 2022; Robinson *et al.,* 2014; Ainslie *et al.,* 2022). These particles are acted upon by internal elastic forces causing them to oscillate back and forth around their positions of equilibrium (i.e., their positions in the absence of the sound wave). This creates alternating regions of compressions and rarefactions allowing the sound wave to propagate. For longitudinal waves, the direction of propagation is parallel to the line along which the particles oscillate. The propagation of a sinusoidal sound wave is depicted in Figure 13-2.

Several quantities may be used to describe a sound wave, such as pressure and particle motion (e.g., displacement, velocity, and acceleration). All metrics used in this report are defined in terms of sound pressure, which is defined as the difference between the instantaneous total pressure and the pressure that would exist in the absence of sound (Robinson *et al.,* 2014). Sound pressure is the component of sound that all marine mammals and some fish species are sensitive to. There are several metrics that are commonly used to quantify sound in terms of pressure (such as zero-to-peak sound pressure, root-mean-square (rms) sound pressure, and sound exposure), and these are discussed in subsequent sections of this report. It is noted that many fish species are sensitive to the particle motion component of sound (Nedelec *et al.,* 2016). However, injury thresholds for fish are currently only well-established in terms of sound pressure (Popper *et al.,* 2014).

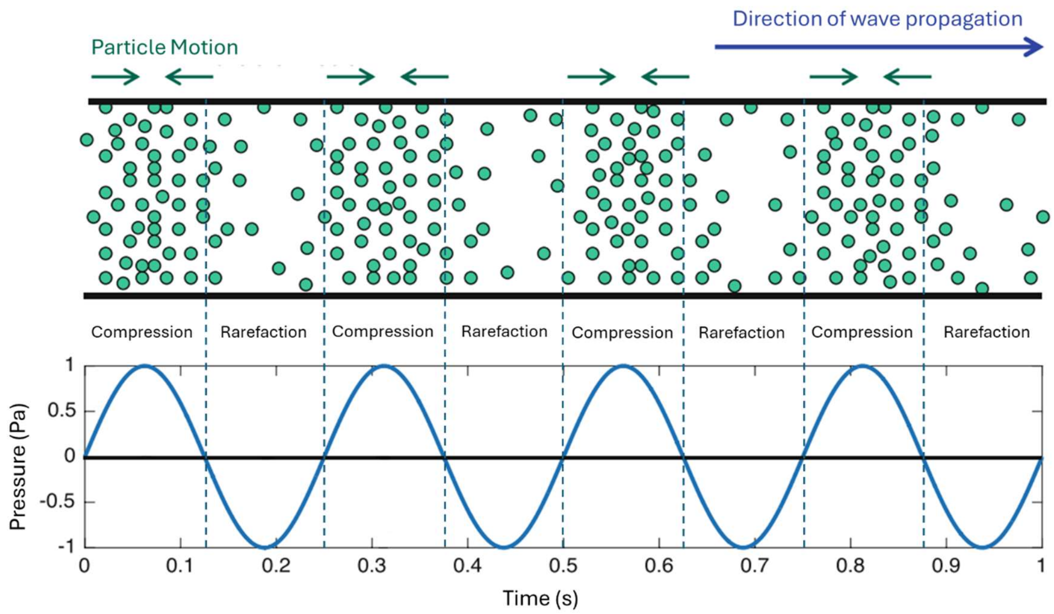

Figure 13-2: Depiction of sinusoidal sound wave propagation

Noise is also a sound but is typically considered as unwanted sound. Whether a sound is perceived as noise depends primarily on the receptor and the circumstances in which the sound is received (Erbe and Thomas, 2022). Anthropogenic sounds perceived by marine receptors (such as marine mammals) are generally classified as noise, as they can interfere with the normal behaviour of a marine receptor and can potentially cause auditory injury and behavioural disturbance (Southall *et al.,* 2019; National Marine Fisheries Service (NMFS), 2018).

13.2.2 ACOUSTIC QUANTITIES AND LEVELS

All metrics used in this assessment are defined in terms of sound pressure, signified by a real-valued time-varying function $p(t)$ in units of Pascal (Pa). Since sound pressure varies with time, it is useful to quantify it using a number of metrics (e.g., mean-square sound pressure, root-mean-square (rms) sound pressure, sound exposure etc.). Such metrics are often expressed relative to a reference value on a logarithmic scale in decibels (dB) and when expressed in this way they are referred to as "levels". An acoustic power quantity, Q, is defined as a level in decibels as (ISO, 2017; Ainslie *et al.,* 2022)

$$L_Q \triangleq 10\log_{10}\left(\frac{Q}{Q_0}\right) \quad (1)$$

where Q_0 is the reference value of the acoustic power quantity, and $\log_{10}(.)$ is the base 10 logarithm function. The acoustic power quantity and its reference value must have the same units such that the ratio Q/Q_0 is dimensionless (i.e., has no units). Despite the ratio Q/Q_0 being dimensionless, the level L_Q has units of dB relative to Q_0 (denoted as $\mathrm{dB\ re}\ Q_0$). For example, if Q represents squared pressure in units of Pa^2 and Q_0 is a reference value of $1\ \mu\mathrm{Pa}^2$, then the level L_Q has units of $\mathrm{dB\ re\ 1\ \mu Pa^2}$.

Equation (1) can equivalently be written (and is often written) as

$$L_Q \triangleq 20\log_{10}\left(\frac{\sqrt{Q}}{\sqrt{Q_0}}\right). \quad (2)$$

Here, $\sqrt{Q}$ represents an acoustic root-power quantity and $\sqrt{Q_0}$ is its reference value (ISO, 2017; Ainslie *et al.,* 2022). The level L_Q has units of dB re $\sqrt{Q_0}$ when written in the form of equation (2). Using the previous example where Q represents squared pressure in units of Pa^2 (thus $\sqrt{Q}$ has units of Pa) and Q_0 is a reference value of $1\ \mu\mathrm{Pa}^2$ (thus $\sqrt{Q_0}$ is $1\ \mu\mathrm{Pa}$), the level L_Q has units of $\mathrm{dB\ re\ 1\ \mu Pa}$ when written in the form of equation (2). Thus, whilst equations (1) and (2) are numerically equivalent and represent the same level of an acoustic quantity, they are stated as having different units.

Table 13-1 summarises the acoustic levels that are used in this report and their reference values and units when expressed using acoustic power quantities using equation (1) or corresponding acoustic root-power quantities using equation (2). In this report, acoustic levels are generally expressed in terms of acoustic power quantities. They can equivalently be expressed in terms of acoustic root-power quantities (and often are in other texts). The reader should refer to Table 13-1 to see the alternative units that are used when the levels are expressed in terms of acoustic root-power quantities instead of the acoustic power quantities used in this report.

Table 13-1: Acoustic levels and units when expressed using acoustic power quantities and corresponding acoustic root-power quantities

Level (L_Q)	Acoustic power quantity (Q)	Acoustic power reference value (Q_0)	Level units (dB re Q_0)	Acoustic root-power quantity ($\sqrt{Q}$)	Acoustic root-power reference value ($\sqrt{Q_0}$)	Level units (dB re $\sqrt{Q_0}$)
Sound pressure level (SPL), L_p	Mean-square sound pressure, $\overline{p^2}$	$p_0^2 = 1\ \mu\mathrm{Pa}^2$	dB re 1 $\mu\mathrm{Pa}^2$	Root-mean-square sound pressure, $p_{rms} \triangleq \sqrt{\overline{p^2}}$	$p_0 = 1\ \mu Pa$	dB re 1 μPa
Zero-to-peak SPL, $L_{p,pk}$	Squared zero-to-peak sound pressure, p_{pk}^2	$p_0^2 = 1\ \mu\mathrm{Pa}^2$	dB re 1 $\mu\mathrm{Pa}^2$	Zero-to-peak sound pressure, p_{pk}	$p_0 = 1\ \mu Pa$	dB re 1 μPa
Sound exposure level (SEL), L_E	Sound exposure, E	$p_0^2 t_0 = 1\ \mu\mathrm{Pa}^2\mathrm{s}$	dB re 1 $\mu\mathrm{Pa}^2\mathrm{s}$	Root sound exposure, $\sqrt{E}$	$p_0\sqrt{t_0} = 1\ \mu\mathrm{Pa}\sqrt{\mathrm{s}}$	dB re 1 $\mu\mathrm{Pa}\sqrt{\mathrm{s}}$
Source level (SL), L_S	Source factor, F_S	$p_0^2 r_0^2 = 1\ \mu\mathrm{Pa}^2\mathrm{m}^2$	dB re 1 $\mu\mathrm{Pa}^2\mathrm{m}^2$	Root source factor, $\sqrt{F_S}$	$p_0 r_0 = 1\ \mu\mathrm{Pa\ m}$	dB re 1 μPa m
Energy source level (ESL), $L_{S,E}$	Energy source factor, $F_{S,E}$	$p_0^2 r_0^2 t_0 = 1\ \mu\mathrm{Pa}^2\mathrm{m}^2\mathrm{s}$	dB re 1 $\mu\mathrm{Pa}^2\mathrm{m}^2\mathrm{s}$	Root energy source factor, $F_{S,E}$	$p_0 r_0\sqrt{t_0} = 1\ \mu\mathrm{Pa\ m}\sqrt{\mathrm{s}}$	dB re 1 $\mu\mathrm{Pa\ m}\sqrt{\mathrm{s}}$
SPL spectral density level, $L_p(f)$	Mean-square sound pressure per unit frequency, $\overline{p^2}/\Delta f$	$p_0^2/f_0 = 1\ \mu\mathrm{Pa}^2/\mathrm{Hz}$	dB re 1 $\mu\mathrm{Pa}^2/\mathrm{Hz}$	Root-mean-square sound pressure per root unit frequency, $p_{rms}/\sqrt{\Delta f}$	$p_0/\sqrt{f_0} = 1\ \mu\mathrm{Pa}/\sqrt{\mathrm{Hz}}$	dB re 1 $\mu\mathrm{Pa}/\sqrt{\mathrm{Hz}}$
SEL spectral density level, $L_E(f)$	Sound exposure per unit frequency, $E/\Delta f$	$p_0^2 t_0/f_0 = 1\ \mu\mathrm{Pa}^2\mathrm{s}/\mathrm{Hz}$	dB re 1 $\mu\mathrm{Pa}^2\mathrm{s}/\mathrm{Hz}$	Root sound exposure per root unit frequency, $\sqrt{E}/\sqrt{\Delta f}$	$p_0\sqrt{t_0}/\sqrt{f_0} = 1\ \mu\mathrm{Pa}\sqrt{\mathrm{s}}/\sqrt{\mathrm{Hz}}$	dB re 1 $\mu\mathrm{Pa}\sqrt{\mathrm{s}}/\sqrt{\mathrm{Hz}}$

13.2.3 SOUND PRESSURE LEVEL

Before defining the sound pressure level (SPL), it is useful to first define the root-mean-square (rms) and mean-square sound pressures. The rms sound pressure is defined as the square root of the mean of time-integrated squared pressure over a given time interval (ISO, 2017; Ainslie *et al.,* 2022). The rms sound pressure is defined mathematically as

$$p_{rms} \triangleq \sqrt{\frac{1}{T}\int_{t_1}^{t_2} p^2(t)\,dt} \tag{3}$$

where $T \triangleq t_2 - t_1$ is the time interval in seconds (s) that the rms sound pressure is calculated over. The rms sound pressure has units of Pa. The rms sound pressure is a time-averaged quantity and it is important that the time interval that the averaging is performed over is stated. This is particularly true for transient waveforms since different averaging time intervals can result in very different rms sound pressures. This is depicted in Figure 13-3, which shows the rms sound pressure of a transient waveform when calculated over time intervals of 0-1 ms and 0-5 ms (shown by $p_{rms,1}$ and $p_{rms,2}$ in the figure, respectively). Evidently, the different time intervals result in very different rms sound pressure values. The mean-square sound pressure is defined as

$$\overline{p^2} \triangleq p_{rms}^2 \tag{4}$$

and has units of Pa^2. The SPL can be defined in terms of the mean-square sound pressure as

$$L_p \triangleq 10\log_{10}\left(\frac{\overline{p^2}}{p_0^2}\right) \tag{5}$$

where p_0 is the reference sound pressure of $1\ \mu\mathrm{Pa}$ and the SPL has units of $\mathrm{dB\ re\ 1\ \mu Pa^2}$.

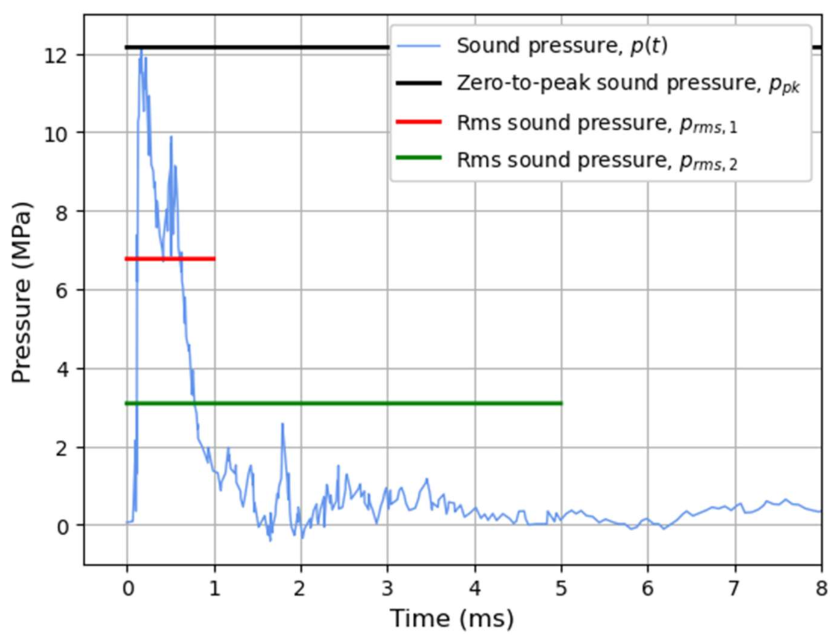

Figure 13-3: Rms sound pressures calculated over different time intervals and zero-to-peak sound pressure for a transient sound pressure waveform

13.2.4 ZERO-TO-PEAK SOUND PRESSURE LEVEL

The zero-to-peak sound pressure is defined as the maximum magnitude of sound pressure over a given time interval (ISO, 2017; Ainslie *et al.,* 2022), which can be stated mathematically as

$$p_{pk} \triangleq \max(|p(t)|) \tag{6}$$

where $\max(.)$ denotes the maximum of a function or series of values, and $|.|$ signifies the magnitude/absolute value. The zero-to-peak sound pressure has units of Pa. It is always stated as a positive value but can result from either a positive (compressional) pressure or a negative (rarefactional) pressure (Robinson *et. al.,* 2014). The zero-to-peak sound pressure is also shown graphically for the transient sound pressure in Figure 13-3.

The zero-to-peak SPL is defined in terms of the zero-to-peak sound pressure as

$$L_{p,pk} \triangleq 10\log_{10}\left(\frac{p_{pk}^2}{p_0^2}\right) \tag{7}$$

and has units of $\text{dB re } 1\ \mu\text{Pa}^2$.

13.2.5 SOUND EXPOSURE LEVEL

Sound exposure is defined as the time-integrated squared sound pressure over a given time interval (ISO, 2017; Ainslie *et al.,* 2022), which can be stated mathematically as

$$E \triangleq \int_{t_1}^{t_2} p^2(t)\, dt \tag{8}$$

where t_1 and t_2 signify the time interval that the sound exposure is calculated over. The sound exposure has units of Pa^2s. The sound exposure is often used as a proxy for sound energy (Robinson *et. al.,* 2014).

The sound exposure level (SEL) is defined in terms of the sound exposure as

$$L_E \triangleq 10\log_{10}\left(\frac{E}{p_0^2\, t_0}\right) \tag{9}$$

where p_0 is the reference sound pressure of $1\ \mu\text{Pa}$ and t_0 is the reference time of 1 second (s). The product $p_0^2 t_0$ is thus a reference sound exposure of $1\ \mu\text{Pa}^2\text{s}$ and the SEL has units of $\text{dB re } 1\ \mu\text{Pa}^2\text{s}$.

The sound exposure given by equation (8) is related to the rms and mean-square sound pressures given by equations (3) and (4), respectively, through the relationships

$$E = p_{rms}^2\, T = \overline{p^2}\, T\,. \tag{10}$$

Similarly, the SPL given by equation (5) is related to the SEL given by equation (9) through the relationship

$$L_E = L_p + 10\log_{10}\left(\frac{T}{t_0}\right). \tag{11}$$

For a given sound pressure, $p(t)$, the rms sound pressure and mean-square sound pressure calculated over a given time interval can be interpreted as the constant sound pressure and squared sound pressure, respectively, that would result in the same sound exposure as that of the sound pressure waveform calculated over the same time interval. For example, in Figure 13-3, the sound exposure calculated over the time interval 0-1 ms is the same as the sound exposure that would result from a constant pressure of $p_{rms,1}$ over a time of 1 ms.

13.2.6 CUMULATIVE SOUND EXPOSURE LEVEL

Sound exposures over multiple acoustic events (e.g., multiple sound pulses) can be summed to calculate the cumulative sound exposure (Robinson *et al.,* 2014). The cumulative sound exposure can be defined mathematically as

$$E_C \triangleq \sum_{i=1}^{N} E_i \qquad (12)$$

where E_i is the sound exposure of the $\mathrm{i_{th}}$ acoustic event and N is the number of acoustic events that the cumulative sound exposure is calculated over. The cumulative sound exposure has units of $\mathrm{Pa^2s}$.

The cumulative SEL (cSEL) is defined in terms of the cumulative sound exposure as

$$L_{E,C} \triangleq 10\log_{10}\left(\frac{E_C}{p_0^2 t_0}\right) \qquad (13)$$

and like the SEL has units of $\mathrm{dB\ re\ 1\ \mu Pa^2s}$. Figure 13-4 demonstrates how the cSEL received by a receptor increases over time due to multiple sound exposures.

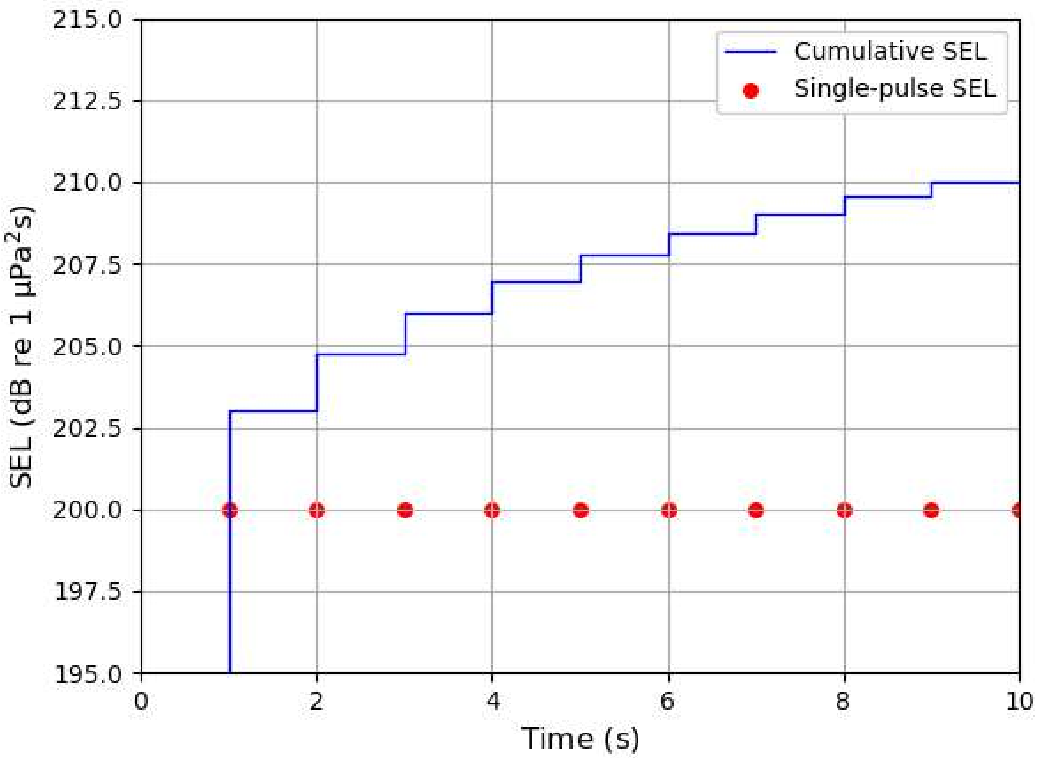

Figure 13-4: Time evolution of cSEL over multiple sound exposures

13.2.7 SOUND PRESSURE SPECTRAL DENSITY

The acoustic metrics discussed so far have been defined in terms of sound pressure in the time domain. It is also useful to describe sound pressure in the frequency domain in the form of spectral densities (e.g., sound pressure, energy, and power spectral densities). The sound pressure spectral density is defined as the Fourier transform of the sound pressure given by

$$P(f) \triangleq \int_{-\infty}^{\infty} p(t) \exp(-j2\pi f t)\, dt \tag{14}$$

where $\exp(.)$ is the natural exponential function, $j \triangleq \sqrt{-1}$ signifies the imaginary part of a complex number, and f denotes frequency in Hertz (Hz). The sound pressure spectral density has units of $\mathrm{Pa/Hz}$ and represents how the sound pressure is distributed with frequency.

The sound pressure spectral density given by equation (14) is a double-sided spectral density function that contains both positive and negative frequency components (Ambardar, 1999). When the sound pressure is real-valued (as is assumed here), the negative frequency components are given by the complex conjugate of the corresponding positive frequency components (i.e., $P(-f) = P^*(f)$ for all non-zero frequencies, where $(.)^*$ denotes complex conjugation).

13.2.8 ENERGY SPECTRAL DENSITY

The double-sided energy spectral density (ESD) of a finite duration sound pressure can be defined in terms of the sound pressure spectral density as $|P(f)|^2$ (ISO, 2017; Ainslie *et al.,* 2022). However, since the negative frequency components of $P(f)$ are the complex conjugate of the positive frequency components, it is possible (and often more convenient) to define the ESD as a single-sided spectral density in terms of non-negative frequencies only. The single-sided ESD can be defined as

$$E(f) \triangleq \begin{cases} |P(0)|^2, & f = 0 \\ 2|P(f)|^2, & f > 0 \end{cases}. \tag{15}$$

The ESD has units of $\mathrm{Pa^2 s/Hz}$ and represents how sound exposure is distributed with frequency. It is therefore also commonly referred to as the sound exposure spectral density. The ESD is typically used for describing transient sound pressures (e.g., sound pulses from piling, explosives etc.).

Using Plancherel's theorem (Ambardar, 1999), it can be stated that

$$E = \int_{-\infty}^{\infty} p^2(t)\,dt = \int_0^{\infty} E(f)\,df \tag{16}$$

which shows that the sound exposure can be calculated by integrating the ESD over all frequencies.

The ESD can also be defined in terms of spectral density levels. The ESD levels are defined as

$$L_E(f) \triangleq 10\log_{10}\left(\frac{E(f)}{p_0^2 t_0 / f_0}\right) \tag{17}$$

where f_0 is the reference frequency of 1 Hz. The term $p_0^2 t_0 / f_0$ is the reference sound exposure per unit frequency of $1\ \mathrm{\mu Pa^2 s/Hz}$ and the ESD levels are in units of $\mathrm{dB\ re\ 1\ \mu Pa^2 s/Hz}$. The ESD levels represent how the SEL is distributed with frequency and can therefore be referred to as the SEL spectral density.

The term ESD is generically used to refer to either the sound exposure spectral density defined by equation (15) or the ESD levels (i.e., the SEL spectral density) defined by equation (17). In this report, the unambiguous terms sound exposure spectral density and SEL spectral density are preferred as they explicitly state the acoustic quantity that is represented by the spectral density.

13.2.9 POWER SPECTRAL DENSITY

For a non-transient or continuous sound pressure (e.g., sound from a vessel, drilling, dredging etc.), it is more appropriate to represent the sound pressure in the frequency domain using a power spectral density (PSD) rather than an ESD. Similar to the discussion on ESD in the previous section, the PSD can be defined as a one-sided spectral density. The one-sided PSD is defined as (Ambardar, 1999)

$$\bar{P}(f) \triangleq \begin{cases} \lim\limits_{T\to\infty} \dfrac{|P_T(0)|^2}{T}, & f = 0 \\ \lim\limits_{T\to\infty} 2\dfrac{|P_T(f)|^2}{T}, & f > 0 \end{cases} \tag{18}$$

where $T \triangleq t_2 - t_1$ signifies the time interval that the PSD is calculated over and $P_T(f)$ is the Fourier transform (see equation (14)) of the sound pressure truncated to the time interval defined by T. In other words, $P_T(f)$ is the Fourier transform of the truncated sound pressure defined by

$$p_T(t) \triangleq \begin{cases} p(t), & t_1 \leq t \leq t_2 \\ 0, & \text{otherwise} \end{cases}. \tag{19}$$

The PSD has units of $\mathrm{Pa}^2/\mathrm{Hz}$ and shows how the mean-square sound pressure is distributed with frequency. It is also commonly referred to as the mean-square sound pressure spectral density.

Plancherel's theorem (Ambardar, 1999) establishes the following relationship

$$\overline{p^2} = \frac{1}{T}\int_{-\infty}^{\infty} p^2(t)\, dt = \int_0^{\infty} \bar{P}(f)\, df\,. \tag{20}$$

which shows that the mean square sound pressure can be calculated in the frequency domain by integrating the PSD over all frequencies.

The PSD can also be defined as spectral density levels. The PSD levels are defined as

$$L_p(f) \triangleq 10\log_{10}\left(\frac{\bar{P}(f)}{p_0^2/f_0}\right) \tag{21}$$

where the term p_0^2/f_0 is the reference mean-square sound pressure per unit frequency of 1 $\mu\mathrm{Pa}^2/\mathrm{Hz}$ and the PSD levels are in units of $\mathrm{dB\ re\ 1\ \mu Pa^2/Hz}$. The PSD levels represent how the SPL is distributed with frequency and can therefore be referred to as the SPL spectral density.

The term PSD is generically used to refer to either the mean-square sound pressure spectral density defined by equation (18) or the PSD levels (i.e., the SPL spectral density) defined by equation (21). In this report, the unambiguous terms mean-square sound pressure spectral density and SPL spectral density are preferred as they explicitly state the acoustic quantity that is represented by the spectral density.

13.2.10 FREQUENCY BAND LEVELS

As discussed in the previous sections, the sound exposure spectral density and mean-square sound pressure spectral density can be integrated over all frequencies to calculate the sound exposure and mean-square sound pressure, respectively. More generally, they can be integrated over a specified frequency band to calculate the sound exposure and mean-square sound pressure within that frequency band.

The sound exposure in a specified frequency band can be calculated by the integral

$$E_f = \int_{f_l}^{f_u} E(f)\, df \tag{22}$$

where f_l and f_u are the lower and upper frequencies of the frequency band. The corresponding SEL in the specified frequency band is then given by

$$L_{E,f} = 10\log_{10}\left(\frac{E_f}{p_0^2 t_0}\right). \tag{23}$$

Similarly, the mean-square sound pressure in a specified frequency band can be calculated as

$$\bar{P}_f = \int_{f_l}^{f_u} \bar{P}(f)df \tag{24}$$

and the corresponding SPL in the specified frequency band is

$$L_{p,f} = 10\log_{10}\left(\frac{\bar{P}_f}{p_0^2}\right). \tag{25}$$

Frequency band levels are commonly presented in terms of decidecade band levels (ISO, 2017; Ainslie *et al.,* 2022). A decidecade band is a passband that is equal to one-tenth of a decade band. Each decidecade band is specified in terms of its centre frequency and lower and upper frequency limits. The centre, lower, and upper frequencies for the n_{th} decidecade band are respectively defined as

$$f_{c,n} \triangleq 10^{n/10} \tag{26}$$

$$f_{l,n} \triangleq 10^{(2n-1)/10} \tag{27}$$

$$f_{u,n} \triangleq 10^{(2n+1)/10}\ . \tag{28}$$

Decidecade bands are commonly referred to as third-octave bands since one-tenth of a decade is approximately equal to one-third of an octave. However, strictly speaking it is incorrect to use these terms interchangeably (ISO, 2017; Ainslie *et al.,* 2022).

The SPL and SEL in decidecade bands can be found by evaluating equations (23) and (25), respectively, with the decidecade bands specified according to (26) to (28). An example SEL spectral density and corresponding decidecade band SELs are shown in Figure 13-5. The decidecade band SELs are higher than the SEL spectral density levels since the sound exposure is integrated over the frequencies within each frequency band. It should also be noted that the bandwidth of each frequency band increases with increasing frequency.

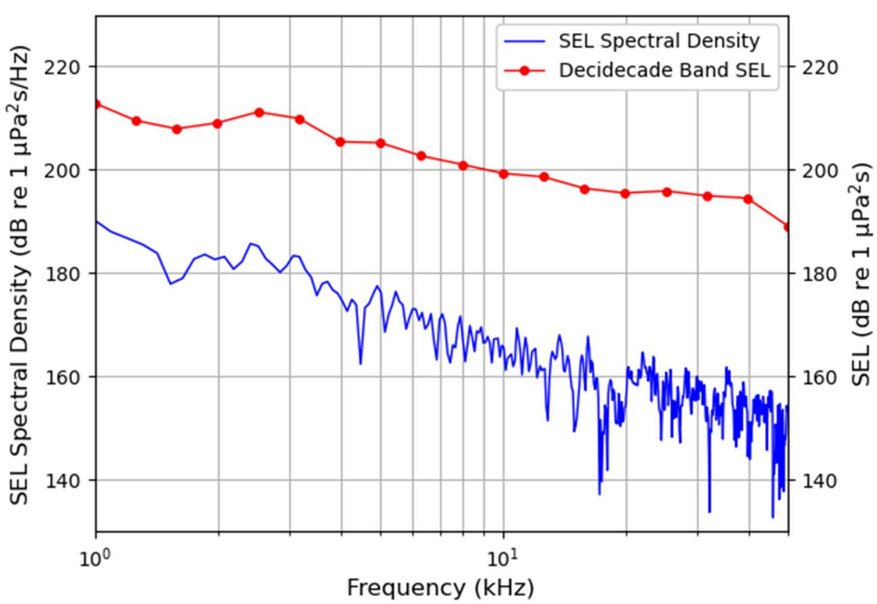

Figure 13-5: Example SEL spectral density and decidecade band SEL

13.2.11 SOURCE LEVEL AND ENERGY SOURCE LEVEL

A number of properties for an acoustic source are defined in terms of its source waveform, $s(t)$. The source waveform is formally defined as (ISO, 2017; Ainslie *et al.,* 2022) "the product of distance in a specified direction, r, from the acoustic centre of a sound source and the delayed far-field sound pressure, $p(t - t_0 + r/c)$, for a specified time origin, t_0, if placed in a hypothetical infinite uniform lossless medium of the same density and sound speed, c, as the actual medium at the location of the source, with identical motion of all acoustically active surfaces as the actual source in the actual medium". Mathematically, the source waveform is defined as

$$s(t) \triangleq p(t - t_0 + r/c)\, r \tag{29}$$

where $p(t - t_0 + r/c)$ is the delayed far-field sound pressure for a specified time origin t_0, r is the distance from the sound source in a specified direction, and c is the speed of sound of the medium.

The source factor is defined in terms of the source waveform as

$$F_S \triangleq \frac{1}{T}\int_{t_1}^{t_2} s^2(t)\, dt \tag{30}$$

where $T \triangleq t_2 - t_1$ signifies the time interval that the squared source waveform is integrated over. The source factor is the mean-square sound pressure of the source waveform and has units of $\mathrm{Pa^2m^2}$. The source level (SL) is defined in terms of the source factor as

$$L_S \triangleq 10\log_{10}\left(\frac{F_S}{p_0^2 r_0^2}\right) \tag{31}$$

where r_0 is the reference distance of 1 m. The SL has units of $\mathrm{dB\ re\ 1\ \mu Pa^2m^2}$ and is sometimes referred to as the SPL source level since it represents the SPL of the source waveform.

If propagation loss (PL) and SPL are known at a given far-field location, the SL can be calculated from

$$L_S = L_P(\boldsymbol{x}) + N_{PL}(\boldsymbol{x}) \tag{32}$$

where $L_P(\boldsymbol{x})$ is the SPL at a far-field location, $\boldsymbol{x}$**,** and $N_{PL}(\boldsymbol{x})$ is the propagation loss at the same location in units of $\mathrm{dB\ re\ 1\ m^2}$ (ISO, 2017; Ainslie *et al.,* 2022).

The energy source factor is defined in terms of the source waveform as

$$F_{S,E} \triangleq \int_{t_1}^{t_2} s^2(t)\, dt \tag{33}$$

and has units of $\mathrm{Pa^2m^2s}$. The energy source factor is the sound exposure of the source waveform.

The energy source level (ESL) is defined in terms of the energy source factor as

$$L_{S,E} \triangleq 10\log_{10}\left(\frac{F_{S,E}}{p_0^2 r_0^2 t_0}\right) \tag{34}$$

and has units of $\mathrm{dB\ re\ 1\ \mu Pa^2m^2s}$. The ESL represents the SEL of the source waveform and is sometimes referred to as the SEL source level.

If the sound exposure propagation loss and SEL are known at a given far-field location, then the ESL can be calculated from (ISO, 2017; Ainslie *et al.,* 2022)

$$L_{S,E} = L_E(\boldsymbol{x}) + N_{PL,E}(\boldsymbol{x}) \tag{35}$$

where $L_E(\boldsymbol{x})$ is the SEL at a far-field location, $\boldsymbol{x}$**,** and $N_{PL,E}(\boldsymbol{x})$ is the sound exposure propagation loss at the same location in units of $\mathrm{dB\ re\ 1\ m^2}$.

13.2.12 WEIGHTED LEVELS

Hitherto, all levels (e.g., SPL, SEL, SPL spectral density, SEL spectral density, SL, ESL) have been defined as unweighted levels. It is common for these levels to be frequency weighted using auditory weighting functions to take into account a marine mammal's hearing ability (Southall *et al.,* 2007; 2019; NMFS, 2018). The unweighted level of an acoustic quantity for a given frequency or frequency band, $L_{Q,f}$, can be frequency weighted as

$$L_{Q,W,f} = L_{Q,f} + W_f \tag{36}$$

where W_f is the level of the frequency weighting in dB for the given frequency or frequency band and $L_{Q,W,f}$ is the frequency weighted level of the acoustic quantity. Frequency weighting is generally applied to SPL and SEL like metrics (e.g., SPL, SEL, SPL spectral density, SEL spectral density, SL, ESL etc.). The zero-to-peak SPL metric is typically unweighted.

In this report, when a level has been frequency weighted it will be explicitly referred to as a weighted level (e.g., weighted SPL, weighted SEL etc.). On the contrary, if the term "weighted" is not used when referring to a level it implicitly means that the level is unweighted (e.g., SPL and SEL refer to the unweighted SPL and SEL).

13.2.13 IMPULSIVE AND NON-IMPULSIVE NOISE

Underwater noise can generally be categorised as either being impulsive or non-impulsive (Southall *et al.,* 2019; NMFS, 2018). The distinction between impulsive and non-impulsive noise is important because these different types of noise have different characteristics and impact marine mammals and other receptors differently. As such, different thresholds are used to assess potential impacts to marine mammals from impulsive and non-impulsive noise.

Impulsive noise is defined as noise that is typically transient, brief (less than 1 second), broadband, and consists of high zero-to-peak sound pressure with rapid rise time and rapid decay (NMFS, 2018). Impulsive noise includes, for example, noise from piling, airgun arrays, and explosives.

Non-impulsive noise is defined as noise that can be broadband, narrowband or tonal, brief or prolonged, continuous or intermittent and typically does not have a high peak sound pressure with rapid rise/decay time that impulsive sounds do (NMFS, 2018). Non-impulsive noise includes, for example, noise from vessels, drilling, and dredging.

13.3 MODELLING METHODOLOGY

To estimate the underwater noise levels that may result from the construction and operation of the Proposed Development, predictive underwater noise modelling has been conducted. Noise modelling has been conducted to estimate the noise levels and potential impacts from piling, dredging, and rock blasting. Two different models have been used to estimate the potential impacts from these activities. An acoustic propagation model has been used to estimate noise levels received by marine mammals during the piling and dredging activities, whilst an explosive blasting model has been used to estimate noise levels received by marine mammals during the rock blasting.

13.3.1 ACOUSTIC PROPAGATION MODEL

Various models can be used for acoustic propagation modelling such as parabolic equation, ray tracing, normal mode, wavenumber integration, energy flux density and semi-empirical models (Jensen *et al.,* 2011). The Venterra in-house underwater noise modelling software has been used for this assessment. The Venterra model uses the range-dependent acoustic model (RAM) developed by Collins (1992) for modelling low-frequency sound propagation and the Bellhop Gaussian beam ray tracing model (Porter and Liu, 1994) for modelling high-frequency sound propagation. For the modelling of piling and dredging conducted in this assessment, RAM has been used to model frequencies up to and including 350 Hz and the Bellhop ray tracing model has been used for modelling frequencies higher than 350 Hz. The Venterra model incorporates:

- A bathymetric grid to account for the influence of varying bathymetry
- Range and depth dependent sound speed profiles
- Acoustic properties of the predominant sediments in the modelling area (sound speed, attenuation, sediment density)
- Frequency-dependent propagation effects (e.g., volume attenuation, reflection, scattering at different frequencies)
- Properties of the acoustic sources (e.g., frequency content of the sound generated, pulse duration and interval for pulsed sources, duration of activity etc.)
- Movement of receptors when calculating received cSEL (e.g., the model incorporates receptor swim speed, depth, and trajectory).

13.3.1.1 ENVIRONMENTAL DATA

The Venterra model accounts for site-specific environmental conditions and incorporates a bathymetric grid, depth varying sound speed profiles, and geo-acoustic properties of the sediment. The data sources that are used in the model to provide site-specific environmental conditions are presented in the following sections.

Bathymetry

Accurate bathymetry data is important for sound propagation modelling since the seabed strongly influences the propagation characteristics of sound. In shallow water regions, there is significant interaction of the sound with the seabed through reflections and scattering effects, which typically results in stronger attenuation. In deeper waters, there is less sound interaction with the seabed and attenuation due to bottom loss is generally lower than in shallow waters, which can result in longer-range propagation (Jensen *et al.,* 2011).

The bathymetry data that has been used in the propagation model is provided by European Marine Observation and Data network (EMODnet), which is a high-resolution digital terrain model for European Seas (EMODnet Bathymetry Consortium, 2020). The EMODnet bathymetry is provided at a spatial resolution of 1/16 arc minutes and is based on data from almost 10,000 bathymetric surveys. The bathymetry data used in the model is shown in Figure 13-6.

Sediment Properties

The types of sediments in an area affect sound propagation through reflection, attenuation, and scattering effects (Jensen *et al.,* 2011). Sediment parameters have the biggest influence over far field sound levels, as they dictate how much sound energy is absorbed by the sediment and how much is reflected from the seabed and remains in the water column.

Sediments in the region of the Proposed Development are shown in Figure 13-7 (Vasquez *et al.,* 2021). There are areas of rock and other hard substrates in the immediate vicinity of the Proposed Development Boundary. In the wider region, sediments are mainly comprised of a mixture of sands and other coarse sediments like gravels as well as softer sediments like clays and silts. Denser substrates such as rock, sand, and gravel generally result in longer range sound propagation compared to softer sediments like clays and silts (Jensen *et al.,* 2011). This is because more sound energy is reflected from harder substrates and remains in the water column, whilst softer sediments absorb more sound resulting in larger propagation losses (Jensen *et al.,* 2011).

The Venterra propagation model is restricted to modelling the seabed as being comprised of a single substrate with associated geo-acoustic properties. The modelling has been conducted assuming a sandy/gravelly seabed to reflect the predominant sediments in the wider region of the Proposed Development Boundary location. The geo-acoustic properties associated with the seabed that have been used in the modelling are shown in Table 13-2 (Jensen *et al.,* 2011).

Table 13-2: Sediment properties included in the propagation model

Sediment property	Value
Substrate	Sand/gravel
Sound speed in sediment	1,725 m/s
Sediment attenuation co-efficient	0.7 dB/λ
Sediment density	1,950 kg/m^3

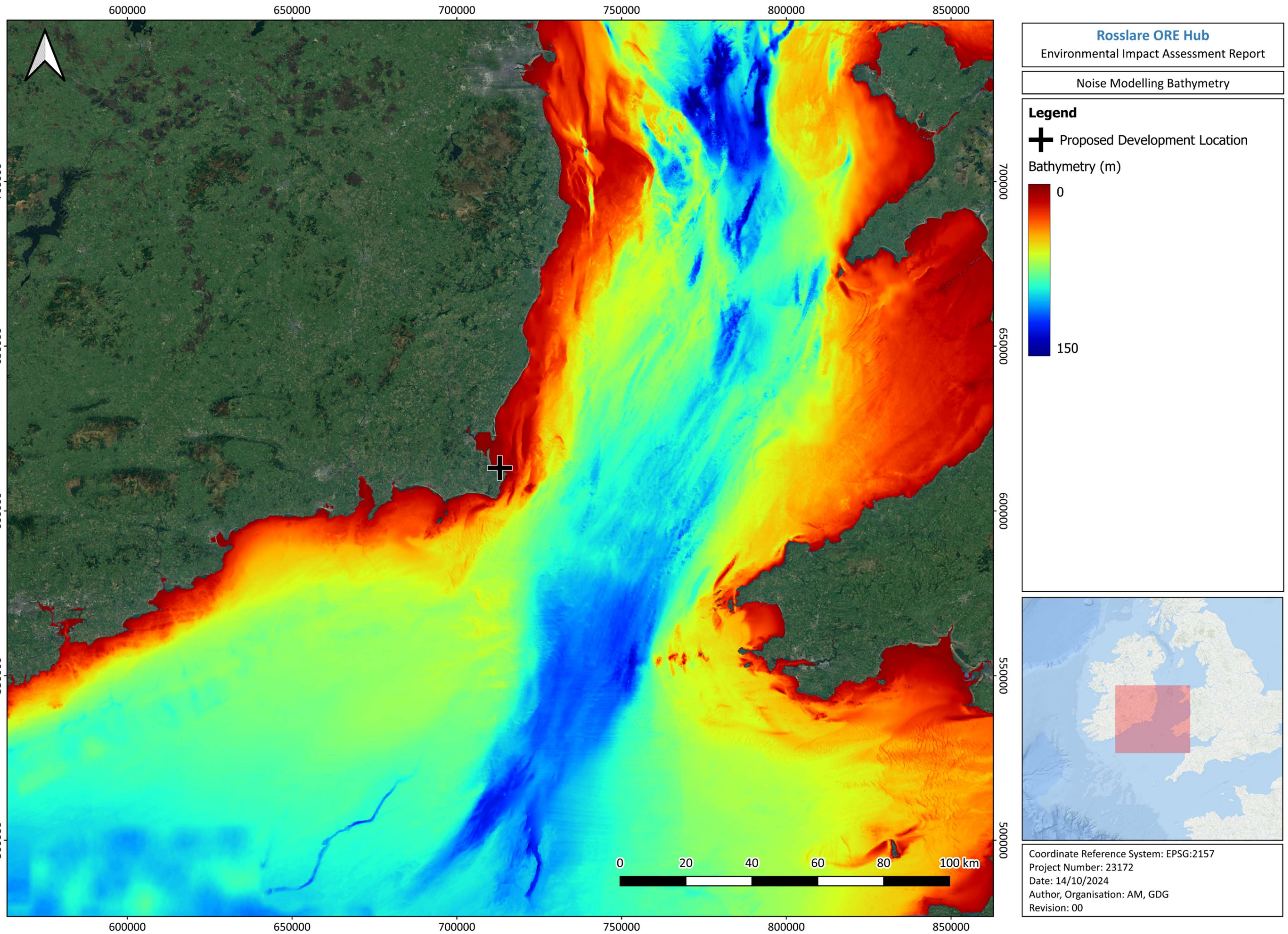

Figure 13-6: Bathymetry in the region of the Proposed Development

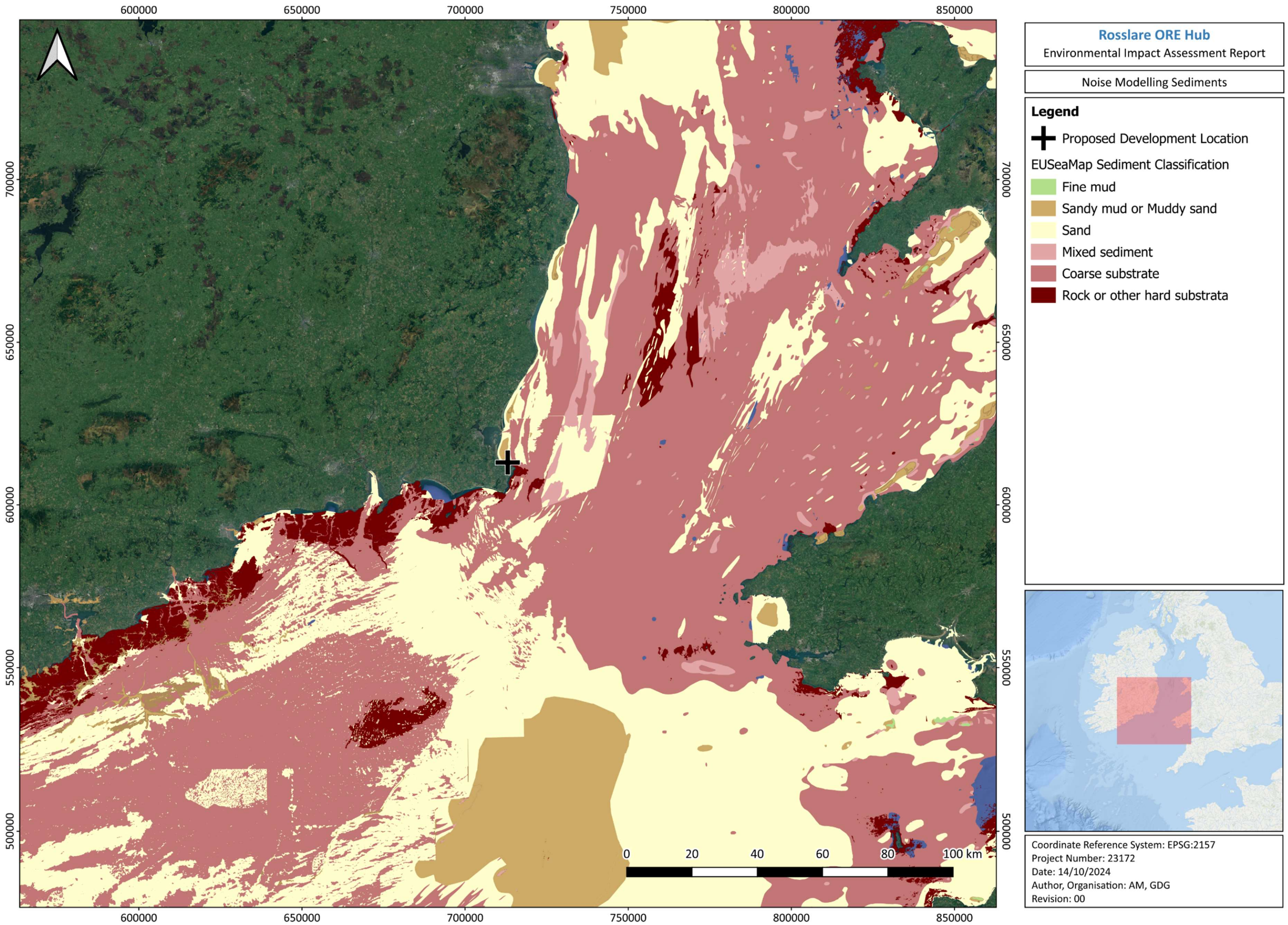

Figure 13-7: Sediments in the region of the Proposed Development

Sound Speed Profiles

A major factor that influences sound propagation in water is the sound speed profile (SSP) through the water column, which affects how sound refracts as it propagates through the water. The Venterra propagation model allows for geographically and depth varying SSPs. Sound speed data can be derived from water column temperature and salinity data (Jensen *et al.,* 2011).

SSPs for the propagation modelling are derived from monthly average temperature and salinity profiles from the World Ocean Atlas (WOA) 2018 database (Garcia *et al.,* 2019). Monthly average SSPs for the modelling region are shown in Figure 13-8. The warmer surface temperatures in the summer months (e.g. June, July, August, and September) result in slightly downward refracting SSPs, whilst colder surface temperatures in winter months (e.g. January, February, March, and April) result in slightly upward refracting SSPs. During summer months, sound will be refracted downwards and will interact more with the seabed resulting in stronger attenuation. Conversely, during winter months sound will be refracted upwards and there will be less interaction with the seabed resulting in less attenuation. Longer-range propagation is therefore expected during winter months. Sound loss from seabed absorption is additive over long distances (Jensen *et al.,* 2011). The influence of the SSP on sound levels will not be as noticeable over smaller distances (e.g., within several hundred metres) but will be more pronounced over larger distances (e.g., over several kilometres).

Dredging and piling at the Proposed Development will be conducted throughout the year. The modelling has therefore been conducted using an SSP representative of winter months that will result in longer-range propagation as this will provide conservative results. Specifically, the January SSP shown in Figure 13-8 has been used in all modelling scenarios.

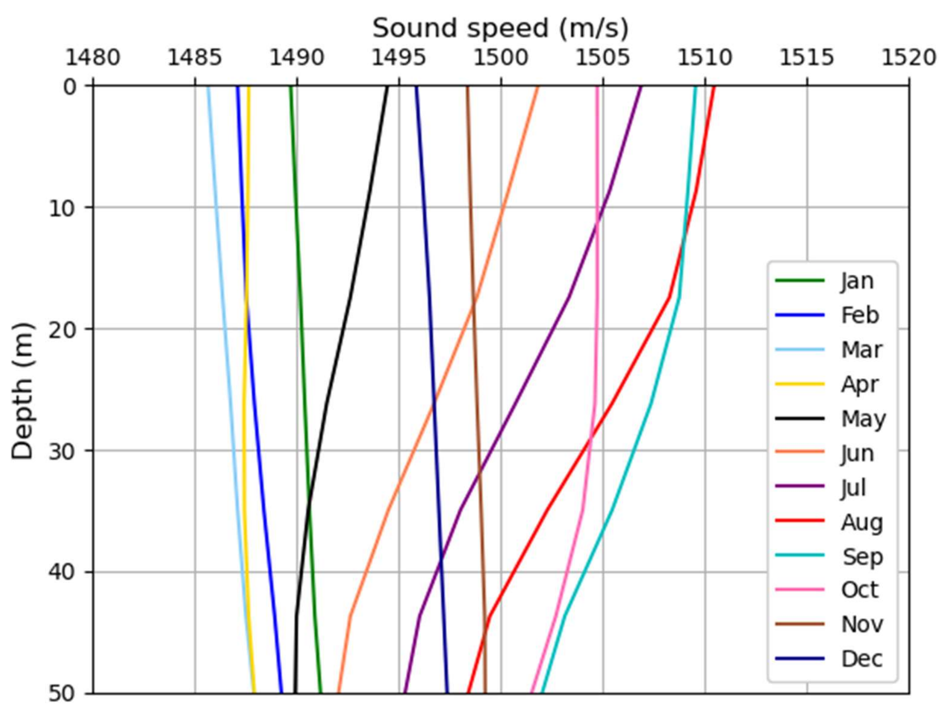

Figure 13-8: Monthly average SSPs derived for the modelling region

Source Characterisation

One of the primary inputs to the acoustic propagation model is a frequency spectrum describing the sound levels generated by the source under consideration. The source frequency spectra and other source characteristics used in the modelling for the piling and dredging modelling scenarios are described in the following sections.

Piling

A pile under percussive driving is a complex acoustic source. The noise levels generated during piling can depend on many factors, such as hammer energy and other properties of the hammer, dimensions and material properties of the pile, water depth, and seabed properties. The hammer energy is thought to have the biggest influence on the sound levels generated, with higher hammer energies typically generating higher noise levels (Robinson *et al.,* 2007; von Pein *et al.,* 2022).

To derive ESLs for an equivalent monopole point source for use in the piling modelling, a representative decidecade band ESL spectrum derived from measurements of piling with an 800 kJ hammer has been used (Ainslie *et al.,* 2012). It is expected that piling at the Proposed Development will be conducted using a hammer with a capacity no greater than 240 kJ. The piling will be initiated with a soft start where the hammer is operated at a lower energy and the hammer energy will gradually be increased over time until the maximum energy is reached. The decidecade band ESL spectrum from Ainslie *et al.* (2012) has been scaled to account for the different hammer energies that will be used during piling at the Proposed Development. It has been assumed that the ESL scales linearly with hammer energy (i.e., a doubling of hammer energy results in a doubling of sound exposure), which has been demonstrated by measurements made during piling (Robinson *et al.,* 2007) and finite element modelling (von Pein *et al.,* 2022). Figure 13-9 shows decidecade band ESLs used in the modelling for different hammer energies.

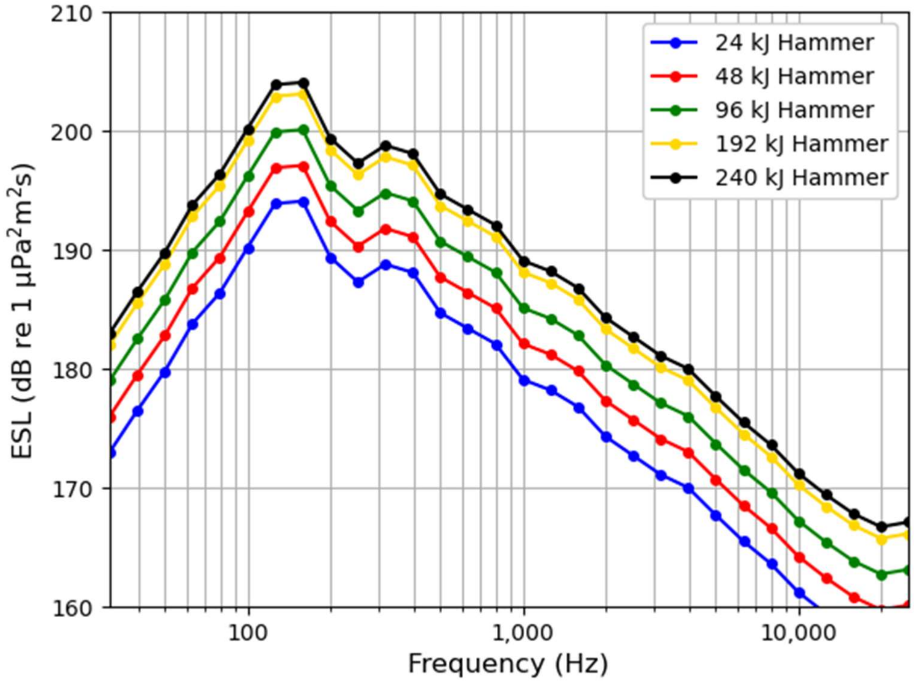

Figure 13-9: Decidecade band ESLs used in the modelling for piling.

In the modelling, it has been assumed that installation of a pile will commence at a soft start energy of 24 kJ (10% of the maximum hammer energy) and the hammer energy will gradually be ramped up over time until the maximum hammer energy of 240 kJ is reached. It is estimated that each pile will take approximately three hours to drive to full penetration depth (Chapter 4: Project Description). The piling procedure (including durations and blow rates at different hammer energies) assumed in the modelling for the installation of each pile is shown in Table 13-3. The (broadband) ESL and zero-to-peak SPL SL used in the modelling for the different hammer energies throughout the piling procedure are also shown in Table 13-3. The zero-to-peak SPL SLs have been calculated assuming that the zero-to-peak SPL will be no more than 25 dB higher than the SEL. This assumption is based on measurements reported by Bellmann *et al.* (2020) for a range of hammer energies and pile diameters. Thus, the zero-to-peak SPL SLs have been estimated as being 25 dB higher than the corresponding ESLs.

Table 13-3: Piling procedure for the installation of each pile and ESLs and zero-to-peak SPL SLs used in the modelling.

Source	Hammer energy (kJ)	Duration (min)	Blow rate (blows/min)	ESL (dB re 1 µPa^{2}s)	Zero-to-peak SPL SL (dB re 1 µPa^2)
Piling	24	30	20	200.3	225.3
	48	30	20	203.3	228.3
	72	20	30	205.0	230.0
	96	20	30	206.3	231.3

Source	Hammer energy (kJ)	Duration (min)	Blow rate (blows/min)	ESL (dB re 1 μPa^{2}s)	Zero-to-peak SPL SL (dB re 1 μPa^2)
	120	20	30	207.2	232.2
	144	10	30	208.0	233.0
	168	10	30	208.7	233.7
	192	10	30	209.3	234.3
	240	30	30	210.3	235.3

Dredging

Underwater noise levels generated during dredging are highly variable and can depend on numerous factors such as the type of dredger undertaking the work (e.g., trailing suction hopper dredger (TSHD), cutter suction dredger, backhoe dredger etc.), operational conditions of the dredger, the type of sediment being dredged, water depth and other environmental conditions (Jones *et al.,* 2015).

There is limited publicly available information on noise levels generated during dredging activities. Perhaps the most detailed study of noise levels from dredging is Robinson *et al.* (2011), which derived SLs from measurements of six different TSHDs undertaking aggregate extraction in the English Channel and North Sea. Measurements of sound levels were made up to at least 48 kHz for all the dredgers. The highest sound levels from the dredgers were at lower frequencies, up to and including 1 kHz in most cases. Sound energy at higher frequencies beyond 1 kHz was also evident, particularly during full dredging compared to other operational stages (e.g., vessel in transit, turning etc.). SLs during full dredging ranged from approximately 176 - 190 dB re 1 μPa^{2}m^2 for the different dredgers that measurements were made for.

The dredger with the highest SL recorded by Robinson *et al.* (2011) has been used in the modelling to be representative of the underwater noise levels that may be generated during dredging activities at the Proposed Development. The decidecade band SLs used in the modelling for dredging are shown in Figure 13-10. The (broadband) SL and zero-to-peak SPL SL used in the modelling for dredging are summarised in Table 13-4. Zero-to-peak SPL SLs were not reported in Robinson *et al.* (2011). It has conservatively been assumed that the zero-to-peak SPL will be less than 6 dB higher than the SPL. A conservative SL of 196 dB re 1 μPa^{2}m^2 has therefore been assumed in the modelling (Table 13-4).

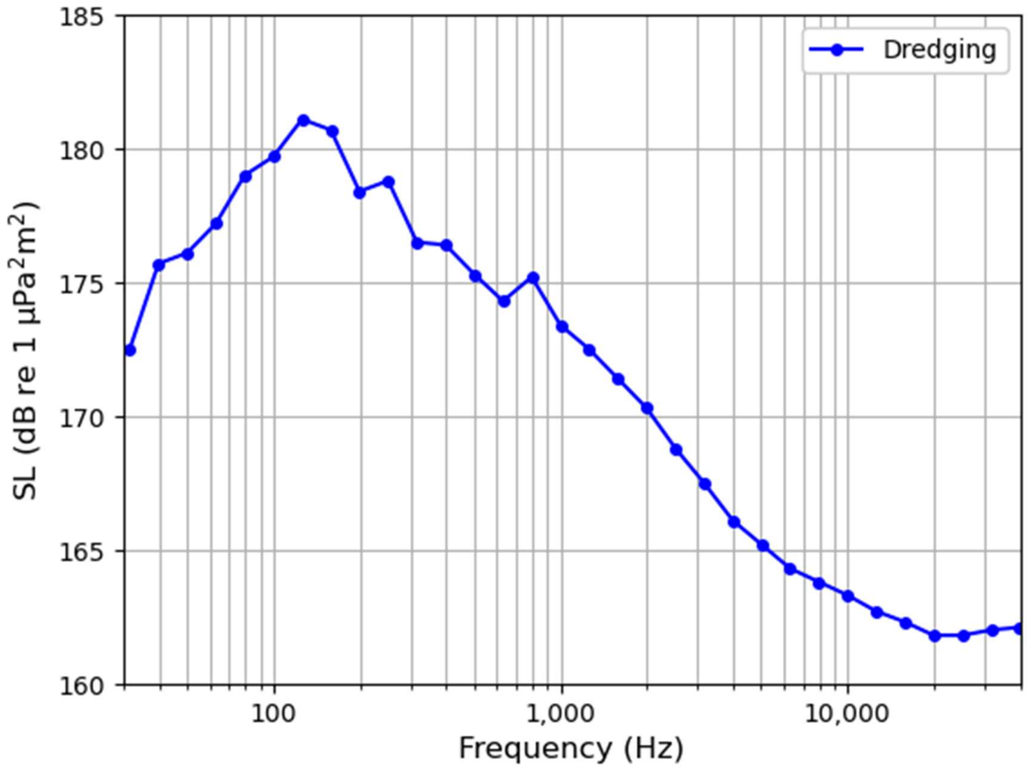

Figure 13-10: Decidecade band SL used in the modelling for dredging

Table 13-4: SL and zero-to-peak SPL SL used in the modelling for dredging

Source	SL (dB re 1 µPa²)	Zero-to-peak SPL SL (dB re 1 µPa²)
Dredging	190.0	196.0

13.3.2 EXPLOSIVE BLASTING MODEL

Rock blasting may be required at the Proposed Development to fracture underlying rock to allow driving of sheet piles along the face of the quay (see Chapter 4: Project Description for details). If rock blasting is required, it is expected that up to fifteen holes will be drilled to a depth of approximately 16 m at a spacing of 2 m in preparation for a single blast. Each hole is expected to receive 50 kg of explosive. The explosives in each hole would be detonated sequentially with a small delay between each explosive. It is anticipated that up to 20 individual blasting days could be required and there would be 2 – 3 weeks between each blasting event. All drilling and blasting would be done from the dry rockfilled platform laid along the line of the quay wall so there would be an effective blanket of rock overburden to dampen noise from each blast (i.e., the blasts are confined by rock rather than being open water detonations).

13.3.2.1 UNDERWATER NOISE FROM OPEN-WATER EXPLOSIVES

When an explosive is detonated in open water, the initial mass of explosive material rapidly expands to produce a large volume of gas at high temperatures and pressures. Initially the gas sphere has a much greater pressure than the surrounding ambient hydrostatic pressure in the water, which is partially alleviated by the creation of a shockwave, and then fully alleviated by the outward flow of water (Cole, 1948). The shockwave that is generated from underwater explosions does not propagate in the same manner as acoustic waves. As such, well established acoustic propagation models (e.g., the parabolic equation and ray tracing models used in the Venterra propagation model) cannot be easily applied for estimating sound levels at distance from underwater explosions. Received sound levels from underwater explosions are therefore generally estimated using semi-empirical equations established from measurements.

The underwater noise from explosive detonations in open water have been well studied (see e.g., Cole, 1948; Slifko, 1967; Swisdack, 1978; Chapman, 1985, 1988; Gaspin *et al.*, 1979; Soloway and Dahl, 2014). Numerous measurements have shown that the zero-to-peak sound pressure from open water detonations can be well approximated by

$$p_{pk} = 52.4 \times 10^6 \left(\frac{w^{1/3}}{r}\right)^{1.13} \tag{37}$$

where p_{pk} is the zero-to-peak sound pressure in Pascals (Pa), w is the explosive charge weight in kilograms (kg) and r is the measurement distance from the explosive charge in meters (m). This relationship has been shown to hold for different charge sizes (Cole, 1948; Slifko, 1967; Swisdack, 1978) and is valid for explosives detonated in the water column or on the seabed.

13.3.2.2 UNDERWATER NOISE FROM ROCK BLASTING

The characteristics of underwater noise generated with confined explosives (e.g., during rock blasting when the explosive is confined within the rock) have been less studied and there are limited measurements reporting underwater noise levels. An experimental study by Nedwell and Thandavamoorthy (1992) involved measurements in water from detonations in bore holes. These measurements indicated that the zero-to-peak sound pressure could be as low as 6% of that generated in equivalent open-water conditions. Hempen *et al.* (2007) showed that the zero-to-peak sound pressure during blasting for rock removal at the Miami Harbour Deepening Project was 19 – 41% of that compared to equivalent open-water detonations. The available results thus show that the zero-to-peak sound pressure from rock blasting could be between 6 – 41% of equivalent open-water detonations, signifying a high degree of uncertainty. In this assessment, a mid-range value of 23.5% is used to estimate the zero-to-peak sound pressure from rock blasting and the values of 6 – 41% are used to provide lower and upper bounds for the estimated zero-to-peak sound pressure. The estimated zero-to-peak sound pressure is therefore given by

$$p_{pk} = 12.3 \times 10^6 \left(\frac{w^{1/3}}{r}\right)^{1.13} . \tag{38}$$

The lower bound to the estimated zero-to-peak sound pressure is given by

$$p_{pk,l} = 3.14 \times 10^{6} \left(\frac{w^{1/3}}{r}\right)^{1.13} \tag{39}$$

and the upper bound to the estimated zero-to-peak sound pressure is given by

$$p_{pk,l} = 21.5 \times 10^{6} \left(\frac{w^{1/3}}{r}\right)^{1.13} \quad . \tag{40}$$

This will provide a range of results for the possible zero-to-peak sound pressures generated during rock blasting at the Proposed Development and will therefore provide a range of estimated distances where potential impacts could occur.

It is noted that the weight of explosive used in the previous equations should be the weight of explosive placed in a single drilled hole and not the combined weight in all holes. This is because there will be a slight delay between the detonations of the explosives in the individual holes. As such, the zero-to-peak pressures from each detonation will not overlap in time and therefore will not add constructively. The zero-to-peak pressure from the overall waveform will show a series of impulses that will each be similar to that from the detonation of a single explosive.

13.4 IMPACT ASSESSMENT THRESHOLDS

Underwater noise can potentially cause injury or disturbance to marine mammals and fish (Richardson *et al.,* 1995; Tougaard, 2016, 2021; Southall *et al.,* 2007, 2019, 2021; NMFS, 2018; Popper *et al.,* 2014). The thresholds that have been adopted in this assessment are discussed in this section.

13.4.1 MARINE MAMMALS

13.4.1.1 PERMANENT AND TEMPORARY THRESHOLD SHIFT

A marine mammal's auditory system is the most sensitive organ to acoustic injury, meaning that injury to the auditory system can occur at lower noise levels than injuries to other tissues (Tougaard, 2016; Southall *et al.,* 2007, 2019; NMFS, 2018). Noise-induced hearing impairment includes permanent threshold shift (PTS) and temporary threshold shift (TTS). PTS is a permanent change in a marine mammal's hearing sensitivity at a given frequency, whilst TTS is a temporary change in hearing sensitivity at a given frequency that a marine mammal will recover from over time. Marine mammals will recover from small amounts of TTS within minutes, whereas it could take hours to days to recover from higher levels of TTS (Tougaard, 2016).

Numerous studies have been conducted to estimate the noise levels required to cause auditory injury to marine mammals (e.g., Tougaard, 2016; Finneran et al., 2010, 2015; Finneran and Schlundt, 2013; Kastelein *et al.,* 2012, 2013; Lucke *et al.,* 2009; Southall *et al.,* 2007, 2019; NMFS, 2018). The thresholds adopted in this assessment for PTS and TTS are those suggested by Southall *et al.* (2019).

Southall *et al.* (2019) categorized marine mammals into the following generalised hearing groups:

- Low frequency (LF) cetaceans
- High frequency (HF) cetaceans
- Very high frequency (VHF) cetaceans
- Phocid carnivores (pinnipeds) in water (PCW) and in air (PCA)
- Other carnivores in water (OCW) and in air (OCA)
- Sirenians (SI).

Of most relevance to this noise assessment are the LF, HF, VHF, and PCW hearing groups, since species belonging to these hearing groups have been observed within the region of the Proposed Development (see Table 13-5). The generalised hearing ranges for the LF, HF, VHF, and PCW hearing groups are shown in Table 13-5 along with species belonging to these hearing groups that have been observed or known to be present in European Atlantic waters (Hammond *et al.,* 2021; Waggitt *et al.,* 2019; Rogan *et al.,* 2018; Berrow *et al.,* 2018). The bold highlighted species are those that were observed during baseline visual and acoustic surveys (see Report 1 of this Technical Appendix).

No species belonging to the SI hearing group are known to inhabit European Atlantic waters and this hearing group has therefore not been considered in the assessment. Whilst some otter species (which belong to the OCW hearing group) are known to be present in Irish waters, they were not observed in the area of the Proposed Development during baseline surveys. An explicit assessment of potential impacts to the OCW hearing group has therefore not been conducted. The generalised hearing range of the OCW hearing group is very similar to that of the PCW hearing group, but the thresholds for potential PTS and TTS impacts are much higher (Southall *et al.,* 2019; NMFS, 2018). Therefore, potential impacts to the OCW hearing group will be lower than those predicted for the PCW hearing group. The potential impacts predicted in this assessment for the PCW hearing group can be used as a worst-case assessment of potential impacts to species belonging to the OCW hearing group (i.e., otters).

Table 13-5: Generalised marine mammal hearing groups and species that are relevant to this assessment

Hearing group	Generalised hearing range	Species
LF	7 Hz to 35 kHz	Blue whale, bowhead whale, fin whale, humpback whale, **minke whale**, northern right whale, sei whale
HF	150 Hz to 160 kHz	Beaked whales, beluga whale, **bottlenose dolphin**, **common dolphin**, killer whale, pilot whale, **Risso's dolphin**, sperm whale, striped dolphin, white-beaked dolphin, white-sided dolphin.
VHF	275 Hz to 160 kHz	**Harbour porpoise**
PCW	50 Hz to 86 kHz	**Grey seal**, **harbour seal**
The listed species are those that have been observed or known to be present in European Atlantic waters (Hammond *et al.,* 2021; Waggitt *et al.,* 2019; Rogan *et al.,* 2018; Berrow *et al.,* 2018). The bold highlighted species are those that were observed to be present in the area of the Proposed Development during baseline visual and acoustic surveys.		

Southall *et al.* (2019) established PTS and TTS thresholds for the different generalised marine mammal hearing groups for both impulsive and non-impulsive noise. The PTS and TTS thresholds for the marine mammal hearing groups considered in this assessment are summarised in Table 13-6. In this assessment, the impulsive noise thresholds are used for assessing potential impacts from the piling and rock blasting activities, whilst the non-impulsive thresholds are used for assessing potential impacts from the dredging. The PTS and TTS thresholds are established using both zero-to-peak SPL and cSEL metrics. The zero-to-peak SPL threshold is unweighted, whilst the cSEL thresholds are based on weighted levels (see Section 13.2.12). Weighted cSELs are evaluated by frequency weighting received (unweighted) SELs using the generalised auditory weighting functions shown in Figure 13-11 (Southall *et al.,* 2019), and the resulting weighted SELs are integrated over the duration of exposure.

Table 13-6: PTS and TTS thresholds for generalised marine mammal hearing groups that are relevant to this assessment

Hearing group	Impulsive noise				Non-impulsive noise			
	Zero-to-peak SPL (dB re 1 µPa^2)		Weighted cSEL (dB re 1 µPa^{2}s)		Zero-to-peak SPL (dB re 1 µPa^2)		Weighted cSEL (dB re 1 µPa^{2}s)	
	PTS	TTS	PTS	TTS	PTS	TTS	PTS	TTS
LF	219	213	183	168	219	213	199	179
HF	230	224	185	170	230	224	198	178
VHF	202	196	155	140	202	196	173	153
PCW	218	212	185	170	218	212	201	181

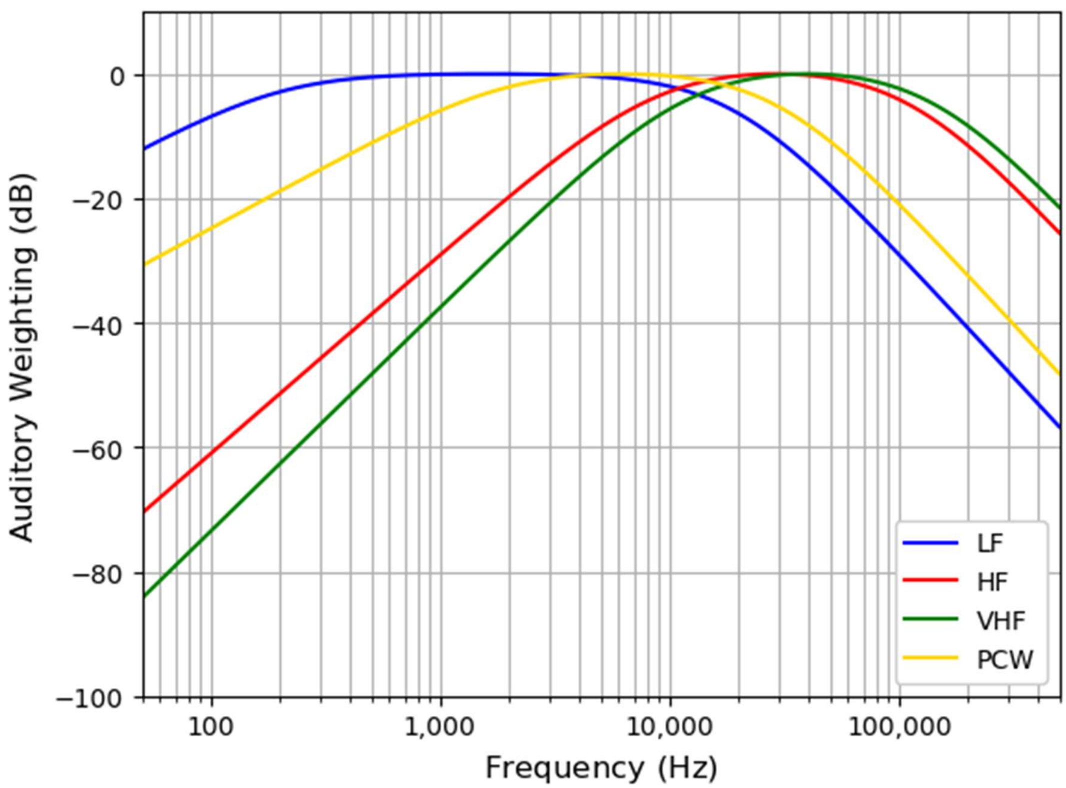

Figure 13-11: Auditory weighting functions for generalised marine mammal hearing groups that are relevant to this assessment

13.4.1.2 BEHAVIOURAL DISTURBANCE

Noise at lower levels than those required to induce PTS or TTS to marine mammals can still have an adverse impact if it alters a marine mammal's normal behaviour (i.e., causes behavioural disturbance). Marine mammals can exhibit varying behavioural responses to underwater sound depending on the level and duration of the noise. Higher levels of noise from piling have been shown to cause marine mammals to be displaced from an area (Brandt *et al.,* 2011, 2016, 2018; Dahne *et al.,* 2013; Cartensen *et al.,* 2006). Noise from piling can also cause disturbance to feeding behaviours (Isojunno *et al.,* 2016; Wisniewska *et al.,* 2018) or changes in swimming behaviour and vocalisation (van Beest *et al.,* 2018; Robertson *et al.,* 2013). Any long-term changes in normal behaviour can have implications for the long-term survival and reproductive success of individuals and could potentially have consequences at a population level (Nabe-Nielsen *et al.,* 2018; Nabe-Nielsen, 2020).

Behaviour disturbance thresholds are not as well defined as thresholds for PTS and TTS. It was concluded in Southall *et al.* (2007; 2021) that thresholds for behavioural disturbance are difficult to conclusively define since behavioural responses to noise are highly variable and context specific. Southall *et al.* (2007; 2021) therefore recommend assessing whether noise from a specific activity could cause disturbance by comparing the circumstances of the situation with empirical studies reporting similar circumstances.

Relevant studies have been reviewed to obtain suitable thresholds where displacement to marine mammals may potentially occur during piling and dredging at the Proposed Development. Disturbance thresholds for rock blasting are not considered here since only one blasting event is expected on a given day and it is expected that there will be two to three weeks between each blasting event (Chapter 4: Project Description). Therefore, the rock blasting is unlikely to cause any long-term disturbance to marine mammals.

Brandt *et al.* (2016) analysed the effect of piling on harbour porpoise from the construction of eight offshore wind farms within the German North Sea between 2009 and 2013. Harbour porpoise monitoring data from static acoustic monitoring using porpoise detectors was combined with data from aerial surveys and data on noise levels. The results showed that detections of harbour porpoise during piling declined by less than 20% at SELs below 145 dB re 1 μPa^2s and that displacement of harbour porpoise at SELs below 145 dB re 1 μPa^2s could not clearly be related to the piling noise.

Thompson *et al.* (2013) showed that harbour porpoises exhibited avoidance from a seismic survey in the Moray Firth at single-pulse SELs of 145 – 151 dB re 1 μPa^2s. Lucke *et al.* (2009) also reported that a captive harbour porpoise consistently showed aversive responses at single-pulse SELs exceeding 145 dB re 1 μPa^2s after exposure to airgun array stimuli. Whilst the observations from Thompson *et al.* (2013) and Lucke *et al.* (2009) are based specifically on airgun array noise, the observations may also be valid for piling since airgun array and piling noise are both impulsive and share similar characteristics.

There has been little work conducted to identify specific thresholds for disturbance to marine mammals from dredging activities. Southall *et al.* (2007) reviewed studies that looked at behavioural disturbance to marine mammals from other non-impulsive sources (such as vessels and drilling). The studies reviewed by Southall *et al.* (2007) suggest that LF cetaceans exposed to non-impulsive noise showed no (to very little) response to noise at SPLs below 120 dB re 1 μPa^2, but an increasing probability of avoidance and other behavioural effects at SPLs from 120 – 160 dB re 1 μPa^2. All the studies reviewed by Southall *et al.* (2007) showed that harbour porpoise (VHF hearing group) exhibited strong avoidance from non-impulsive noise sources at received SPLs above 140 dB re 1 μPa^2. The studies reviewed by Southall *et al.* (2007) also suggested that pinnipeds (PCW hearing group) generally did not show strong behavioural reactions to non-impulsive noise at SPLs below 140 dB re 1 µPa^2.

The thresholds used in this assessment to signify potential displacement of marine mammals from piling and dredging are summarised in Table 13-7. The SEL threshold of 145 dB re 1 µPa^{2}s used in this assessment to signify potential displacement of marine mammals from piling is based on the observations from Brandt *et al.* (2016), Thompson *et al.* (2013), and Lucke *et al.* (2009). The SPL threshold of 140 dB re 1 µPa^2 used to signify potential displacement from dredging is based on the observations of behavioural disturbance to marine mammals from non-impulsive noise reported in Southall *et al.* (2007).

The thresholds in Table 13-7 are used to signify potential displacement of marine mammals from piling and dredging at the Proposed Development. Different marine mammals (even marine mammals from the same hearing group) will likely have different reactions to noise from the piling and dredging. The thresholds in Table 13-7 are not intended to signify thresholds where all marine mammals are disturbed. There will be an increasing likelihood of disturbance with increasing levels above these thresholds. It is also possible that lower levels of behavioural disturbances (such as masking, changes in swimming behaviour, vocalisation etc.) may occur at levels below the thresholds in Table 13-7.

The disturbance thresholds adopted in this assessment (Table 13-7) are predominantly based on observed displacements of harbour porpoises (VHF cetaceans). It is thought that harbour porpoises are more sensitive to underwater noise than other species (Southall *et al.,* 2019; NMFS, 2018; Tougaard, 2016, 2021). Applying these thresholds for predicting disturbance to other marine mammal hearing groups may therefore be conservative.

Table 13-7: Thresholds used in this assessment to signify potential displacement of marine mammals from piling and dredging

Activity	Displacement threshold	Source
Piling	SEL: 145 dB re 1 µPa^{2}s	Brandt *et al.* (2016) Thompson *et al.* (2013) Lucke *et al.* (2009)
Dredging	SPL: 140 dB re 1 µPa^2	Southall *et al.* (2007)

13.4.2 FISH

13.4.2.1 INJURY

Popper *et al.* (2014) have defined criteria for injury to fish species based on a review of publications related to impacts on fish, and fish eggs and larvae from various sources including piling and explosives. Popper *et al.* (2014) is the most comprehensive review available for potential impacts of underwater noise on fish species.

The hearing capability and sensitivity of fish to underwater noise largely depends on the presence or absence of a swim bladder (Popper *et al.,* 2014; Nedelec *et al.,* 2016). Popper *et al.* (2014) derived different injury thresholds for the following groups of fish:

- Fishes with no swim bladder or other gas chamber
- Fishes with swim bladders in which hearing involves the swim bladder or other gas volume
- Fishes with swim bladders but hearing does not involve the swim bladder or other gas volume
- Fish eggs and larvae

The Popper *et al.* (2014) thresholds for injury to fish species from piling are summarised in Table 13-8. No thresholds were derived in Popper *et al.* (2014) for dredging or other similar sources. The thresholds derived for piling have therefore also been used in this assessment to assess potential impacts from dredging.

Popper *et al.* (2014) estimated that injury to fish species from explosives use could result when zero-to-peak SPLs exceeded 229 – 234 dB re 1 µPa^2. The lower threshold value of 229 dB re 1 µPa^2 is used in this assessment when assessing the potential for injury to fish species from the rock blasting.

Table 13-8: Fish injury thresholds for piling

Fish group	Zero-to-peak SPL (dB re 1 µPa^2)	cSEL (dB re 1 µPa^{2}s)		
	Potential mortal injury or recoverable injury	Potential mortal injury	Recoverable injury	TTS
Fish with no swim bladder	213	219	216	186
Fish with swim bladder involved in hearing	207	210	203	186
Fish with swim bladder not involved in hearing	207	207	203	186
Fish eggs and larvae	207	210	N/A	N/A

13.4.2.2 BEHAVIOURAL DISTURBANCE

Documented effects of sound on fish behaviour are variable, ranging from no discernible effect (Wardle *et al.,* 2001) to startle reactions followed by immediate resumption of normal behaviour (Wardle *et al.,* 2001; Hassel *et al.,* 2004). However, there are no well-established thresholds for assessing behavioural disturbance to fish. Popper *et al.* (2014) concluded that there lacked sufficient evidence to recommend specific thresholds that correspond to behavioural disturbance for fish. Disturbance to fish is therefore not quantitively assessed in this report.

13.5 MODELLING RESULTS

This section presents the underwater noise modelling results for the piling, dredging, and rock blasting activities that will be conducted at the Proposed Development and assesses potential impacts to marine mammals and fish using the thresholds discussed in Section 13.4. Before the modelling results are presented, ambient sound levels measured at the Proposed Development are firstly presented and analysed. The analysis of ambient sound levels in the area allows the predicted noise levels from the modelling to be placed in context with existing baseline levels.

13.5.1 AMBIENT SOUND

Ambient sound was recorded at the Proposed Development by the Irish Whale and Dolphin Group (IWDG) to assess baseline sound levels in the area (see Report 1 of this Technical Appendix). Recordings were made using a SoundTrap ST600 HF Long Term Recorder (Ocean Instruments, 2024) that was calibrated with an end-to-end sensitivity of 176.3 dB re 1 µPa. The SoundTrap was configured to sample at 96 kHz for 30 minutes every hour, thus capturing acoustic data up to 48 kHz. The device was deployed for 67 days from April 26 to July 2, 2024, and acquired 804 hours of data.

Figure 13-12 shows a statistical representation of ambient sound decidecade band SPLs that were measured at the Proposed Development on a given day. The sound pressure was measured for 30-minute durations every hour over a 24-hour period and the decidecade band SPLs were calculated for each 30-minute duration. The 10th, 50th, and 90th percentiles and rms of the decidecade band SPLs were then calculated as shown in Figure 13-12.

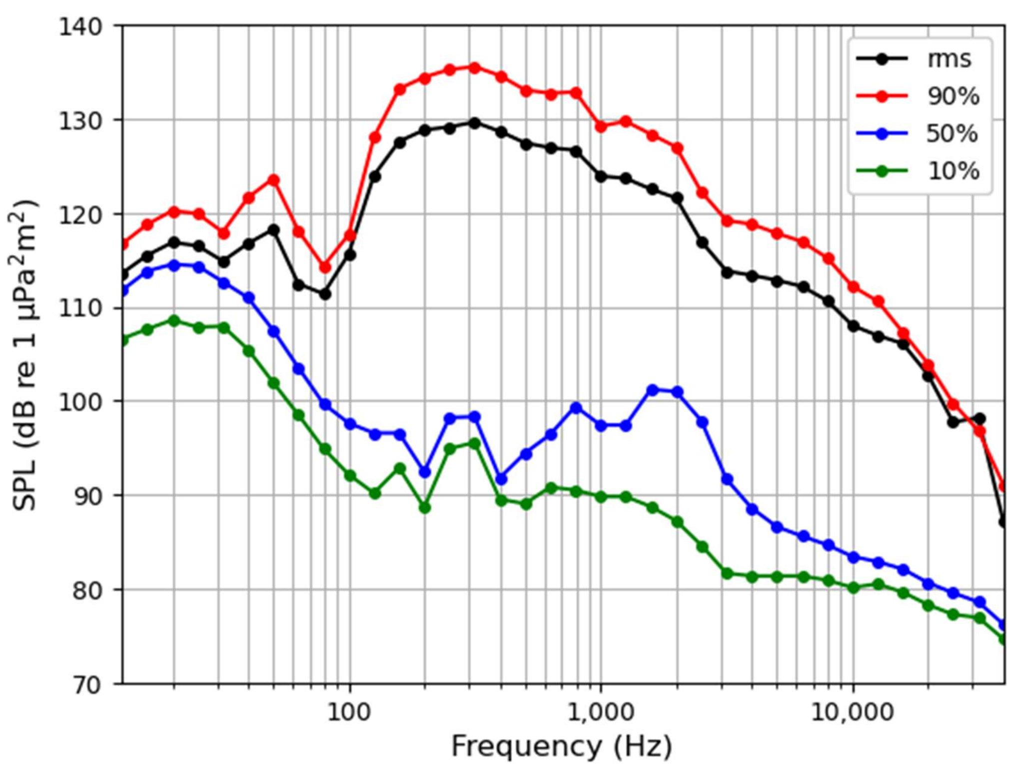

Figure 13-12: Unweighted decidecade band ambient SPL measured at the Proposed Development

The ambient decidecade band SPLs were further analysed by weighting the levels using the Southall *et al.* (2019) auditory weighting functions and calculating the unweighted and weighted broadband SPLs over all frequencies. The unweighted and weighted broadband SPLs are summarised in Table 13-9.

Table 13-9: Unweighted and weighted broadband ambient SPL measured at the Proposed Development on a given day

Hearing group	Ambient SPL (dB re 1 µPa)			
	10%	50%	90%	Rms
UW	109	121	149	143
LF	107	120	147	142
HF	90	102	126	122
VHF	88	98	122	119
PCW	101	115	139	134

13.5.2 PILING

Piling at the Proposed Development has been modelled at the location shown in Figure 13-1. This location was selected as it is the furthest location offshore that piles will be installed and will result in the largest areas of predicted disturbance. The modelling has assumed that six piles will be installed in a single day with each pile installed in three hours following the piling procedure detailed in Table 13-3. A 30-minute downtime period (where no piling is conducted) has been assumed in the modelling between the installation of successive piles.

13.5.2.1 COMPARISON WITH MEASUREMENTS

Before comparing the estimated noise levels from the modelling with impact thresholds for marine mammals and fish, a comparison is made between the model estimated noise levels for the Proposed Development and available measurement data for piling. Bellmann *et al.* (2020) reported SEL and zero-to-peak SPL measurements at a distance of 750 m for various projects involving piling of different diameter piles at different hammer energies. The maximum SEL and zero-to-peak SPL estimated at a distance of 750 m from the modelling for the Proposed Development is compared to the measurements from Bellmann *et al.* (2020) in Figure 13-13. It is noted that the expected diameter of the piles that will be installed at the Proposed Development is 1.219 m. As shown in Figure 13-13, the modelled SEL and zero-to-peak SPL at 750 m for piling at the Proposed Development match well with the available measurement data for similar diameter piles.

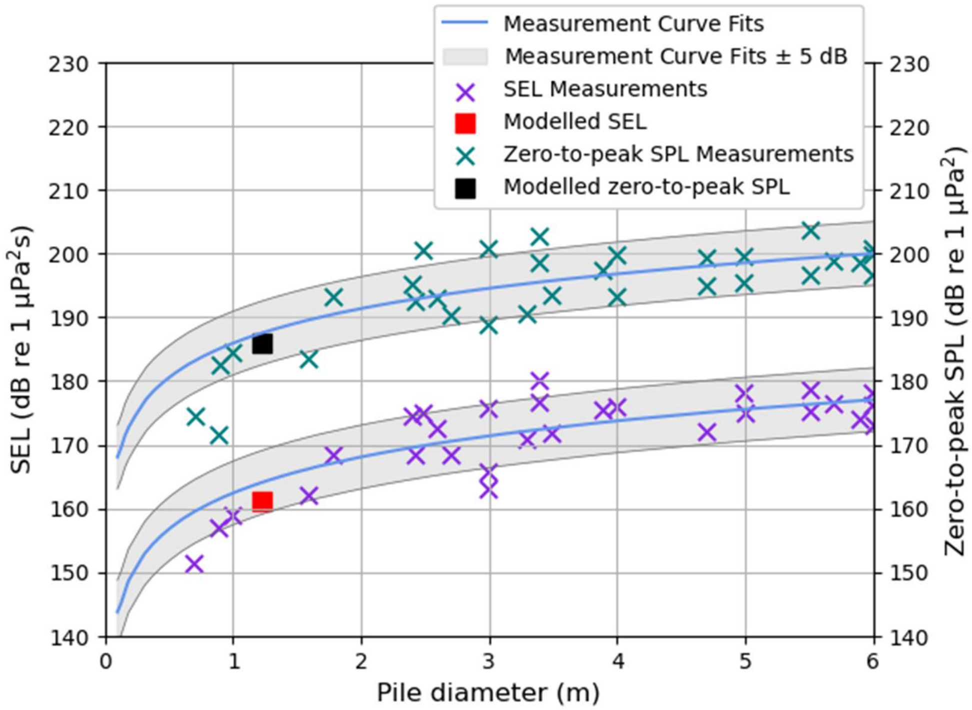

Figure 13-13: Comparison of estimated SEL and zero-to-peak SPL at 750 m from the modelling for the Proposed Development with piling measurement data

13.5.2.2 MARINE MAMMALS

Permanent and Temporary Threshold Shift

The zero-to-peak SPL from pile strikes during piling at the Proposed Development have been estimated and compared to the Southall *et al.* (2019) thresholds for PTS and TTS. The estimated zero-to-peak SPL when the impact hammer is operating at maximum energy of 240 kJ is shown in Figure 13-14. The solid contours in this figure highlight the Southall *et al.* (2019) PTS and TTS thresholds, whilst the dashed contours indicate other zero-to-peak SPL values provided for reference purposes. The maximum predicted distances to the Southall *et al.* (2019) PTS and TTS thresholds for impulsive noise during piling at the Proposed Development are summarised in Table 13-10.

Table 13-10: Maximum predicted distances to zero-to-peak SPL thresholds for PTS and TTS to marine mammals from piling

Hearing group	Zero-to-peak SPL threshold (dB re 1 µPa²)		Maximum distance to threshold (m)	
	PTS	TTS	PTS	TTS
LF	219	213	7	17
HF	230	224	2	4
VHF	202	196	110	270
PCW	218	212	8	20

Weighted SELs have been estimated for each marine mammal hearing group. The LF-weighted, HF-weighted, VHF-weighted, and PCW-weighted SELs for single pile strikes with the hammer operating at the maximum hammer energy of 240 kJ are shown in Figure 13-15, Figure 13-16, Figure 13-17, and Figure 13-18, respectively. To calculate the weighted cSELs received by marine mammals belonging to these hearing groups, weighted SELs from each hammer strike over 24 hours of piling have been estimated. Each pile has been modelled according to the piling procedure detailed in Table 13-3 with six piles installed in 24 hours and a 30-minute downtime between successive piles. Marine mammals have been modelled as swimming away from the piling location from different initial starting distances at different swimming trajectories and swim speeds. The weighted cSEL they receive over 24 hours is then calculated. Distances to PTS and TTS threshold exceedances are reported as the initial starting distance (averaged over the different swim trajectories) a marine mammal must be from the piling location to not be exposed to cSEL above the PTS and TTS thresholds after they swim away at a given swim speed. The predicted distances to PTS and TTS threshold exceedances are shown in Table 13-11.

Table 13-11: Predicted distances to weighted cSEL thresholds for PTS and TTS to marine mammals from piling

Hearing group	Swim speed (m/s)	Weighted cSEL threshold (dB re 1 µPa²s)		Distance to threshold (m)	
		PTS	TTS	PTS	TTS
LF	1.5	183	168	10	2,600
	2.0			10	2,000
	2.5			10	1,400
	3.0			10	780
HF	1.5	185	170	Not exceeded	Not exceeded
	2.0			Not exceeded	Not exceeded
	2.5			Not exceeded	Not exceeded
	3.0			Not exceeded	Not exceeded
VHF	1.5	155	140	30	2,600
	2.0			20	1,800
	2.5			10	1,300
	3.0			10	1,100
PCW	1.5	185	170	Not exceeded	80
	2.0			Not exceeded	40
	2.5			Not exceeded	30

Hearing group	Swim speed (m/s)	Weighted cSEL threshold (dB re 1 µPa²s)		Distance to threshold (m)	
		PTS	TTS	PTS	TTS
	3.0			Not exceeded	20

The results in Table 13-10 and Table 13-11 suggest that the risk of PTS to any marine mammal is low provided that appropriate mitigation is in place (e.g., marine mammal observers (MMO) monitoring a mitigation zone). It is also not expected that TTS will occur to species belonging to the HF hearing group (e.g., dolphins) or the PCW hearing group (e.g., seals) assuming appropriate mitigation is in place. The cSEL results in Table 13-11 suggest that TTS to marine mammals belonging to the LF hearing group (e.g., minke whales) and the VHF hearing group (e.g., harbour porpoise) could occur at large distances from the piling location. It is predicted that marine mammals belonging to the LF and VHF hearing groups that are initially within 2.6 km from the piling location could be subject to cSELs above the TTS thresholds when they swim away at a speed of 1.5 m/s. These distances reduce with increased swim speeds since the marine mammals will get further away from the piling location quicker and will receive lower sound levels per pulse compared to when they swim away at slower speeds (thus the overall cSEL is lower).

Behavioural Disturbance

Disturbance to marine mammals from piling at the Proposed Development has been estimated by comparing the predicted unweighted SEL for single hammer strikes with the adopted behavioural disturbance threshold (see Section 13.4.1.2). The adopted behavioural disturbance threshold is used to signify potential displacement of marine mammals. The predicted unweighted SEL for the hammer operating at maximum energy of 240 kJ is shown in Figure 13-19. The threshold for potential displacement of marine mammals is highlighted in this figure as well as the ambient rms SEL. The ambient rms SEL has been calculated as the ambient rms SPL measured at the Proposed Development location (see Section 13.5.1) over a 1 s exposure time. This level provides an indication at where noise levels from the piling can be expected to drop below ambient sound levels (i.e., provides an estimated level of audibility).

The predicted maximum distances to the adopted threshold for displacement of marine mammals and the rms SEL ambient sound level are shown in Table 13-12. It is predicted that marine mammals could be displaced at distances of 4.6 km from the piling location. As discussed previously, the threshold for displacement does not signify that all marine mammals will be displaced. There will be an increasing probability of displacement with increasing levels above the threshold. The predicted distance to the rms SEL sound level is 5.8 km. Beyond this distance, it is expected that noise from the piling will be below ambient levels.

Table 13-12: Maximum predicted distances from piling to the marine mammal displacement threshold and ambient rms SEL and areas impacted

Threshold	SEL (dB re 1 µPa²s)	Maximum distance (km)	Area (km²)
Displacement of marine mammals	145	4.6	16.3
Ambient rms SEL	143	5.8	26.7

13.5.2.3 FISH

Potential impacts to fish species have been predicted by comparing the estimated zero-to-peak SPL and cSEL with the Popper *et al.* (2014) thresholds. The predicted zero-to-peak SPL with the hammer operating at maximum energy of 240 kJ is shown in Figure 13-20. The predicted distances to the zero-to-peak SPL thresholds for potential mortal injury or recoverable injury are summarised in Table 13-13.

The cSEL received by fish species has been predicted using the same methodology previously described for marine mammals (although the cSEL is unweighted in this case). It has been assumed that mobile fish species will swim away from the piling location at a speed of 1.5 m/s and that fish eggs and larvae that are immobile will remain stationary. The predicted distances to the cSEL thresholds for potential mortal injury, recoverable injury, and TTS are summarised in Table 13-14.

Table 13-13: Maximum predicted distances to zero-to-peak SPL thresholds for potential mortal injury or recoverable injury to fish from piling

Fish group	Zero-to-peak SPL threshold (dB re 1 µPa²)	Maximum distance to threshold (m)
Fishes with no swim bladder	213	17
Fishes with swim bladder involved in hearing	207	46
Fishes with swim bladder not involved in hearing	207	46
Fish eggs and larvae	207	46

Table 13-14: Predicted distances to cSEL thresholds for potential mortal injury, recoverable injury, and TTS to fish from piling

Fish group	Swim speed (m/s)	cSEL threshold (dB re 1 µPa²s)	Distance to threshold (m)
Potential mortal injury			
Fishes with no swim bladder	1.5	219	Not exceeded
Fishes with swim bladder involved in hearing	1.5	210	Not exceeded
Fishes with swim bladder not involved in hearing	1.5	207	Not exceeded
Fish eggs and larvae	Stationary	210	150
Recoverable injury			
Fishes with no swim bladder	1.5	216	Not exceeded
Fishes with swim bladder involved in hearing	1.5	203	Not exceeded
Fishes with swim bladder not involved in hearing	1.5	203	Not exceeded
Fish eggs and larvae	Stationary	N/A	N/A
TTS			
Fishes with no swim bladder	1.5	186	10
Fishes with swim bladder involved in hearing	1.5	186	10
Fishes with swim bladder not involved in hearing	1.5	186	10
Fish eggs and larvae	Stationary	N/A	N/A

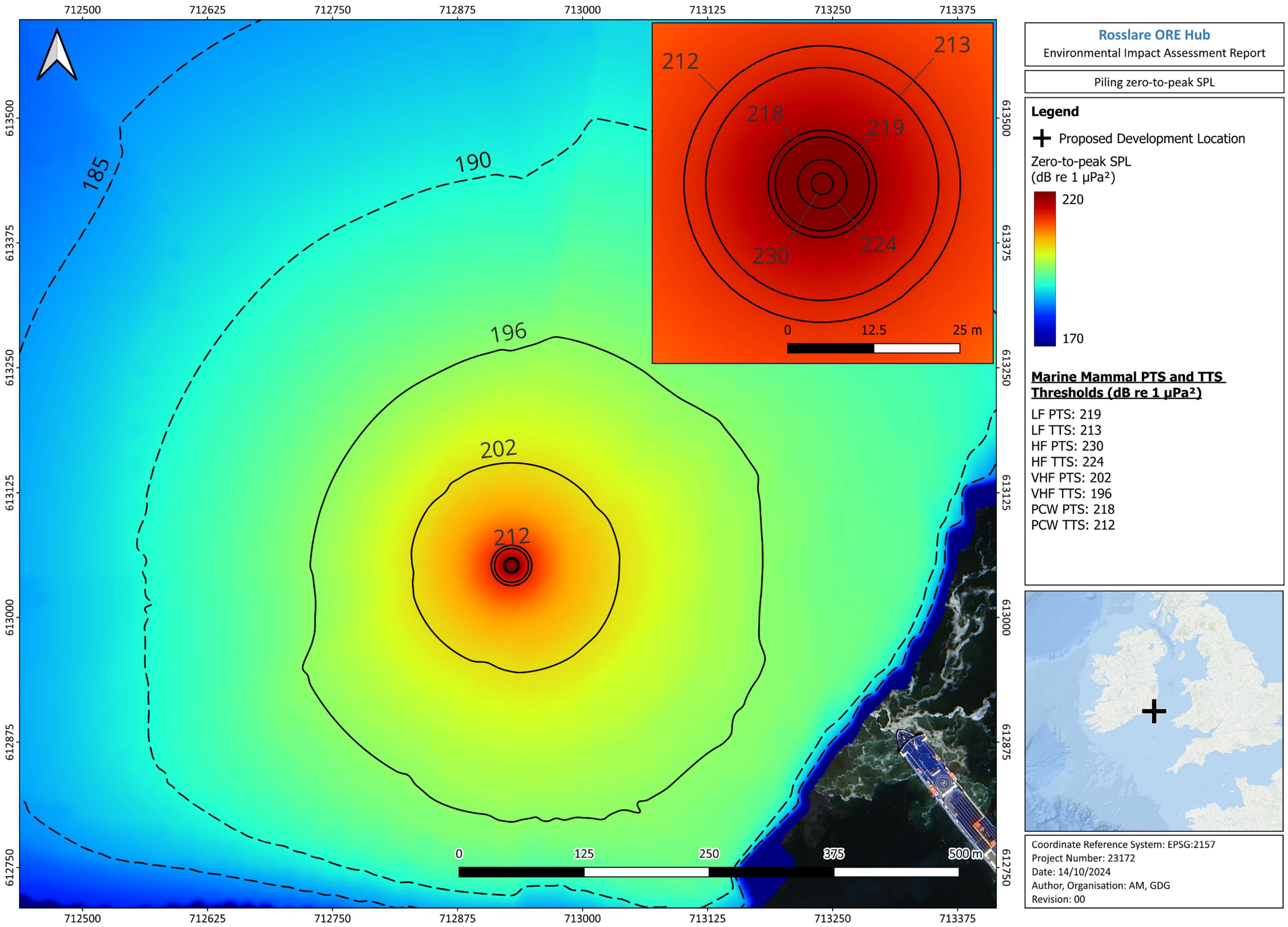

Figure 13-14: Predicted zero-to-peak SPL during piling with the hammer operating at maximum energy of 240 kJ (comparison with marine mammal PTS and TTS thresholds)

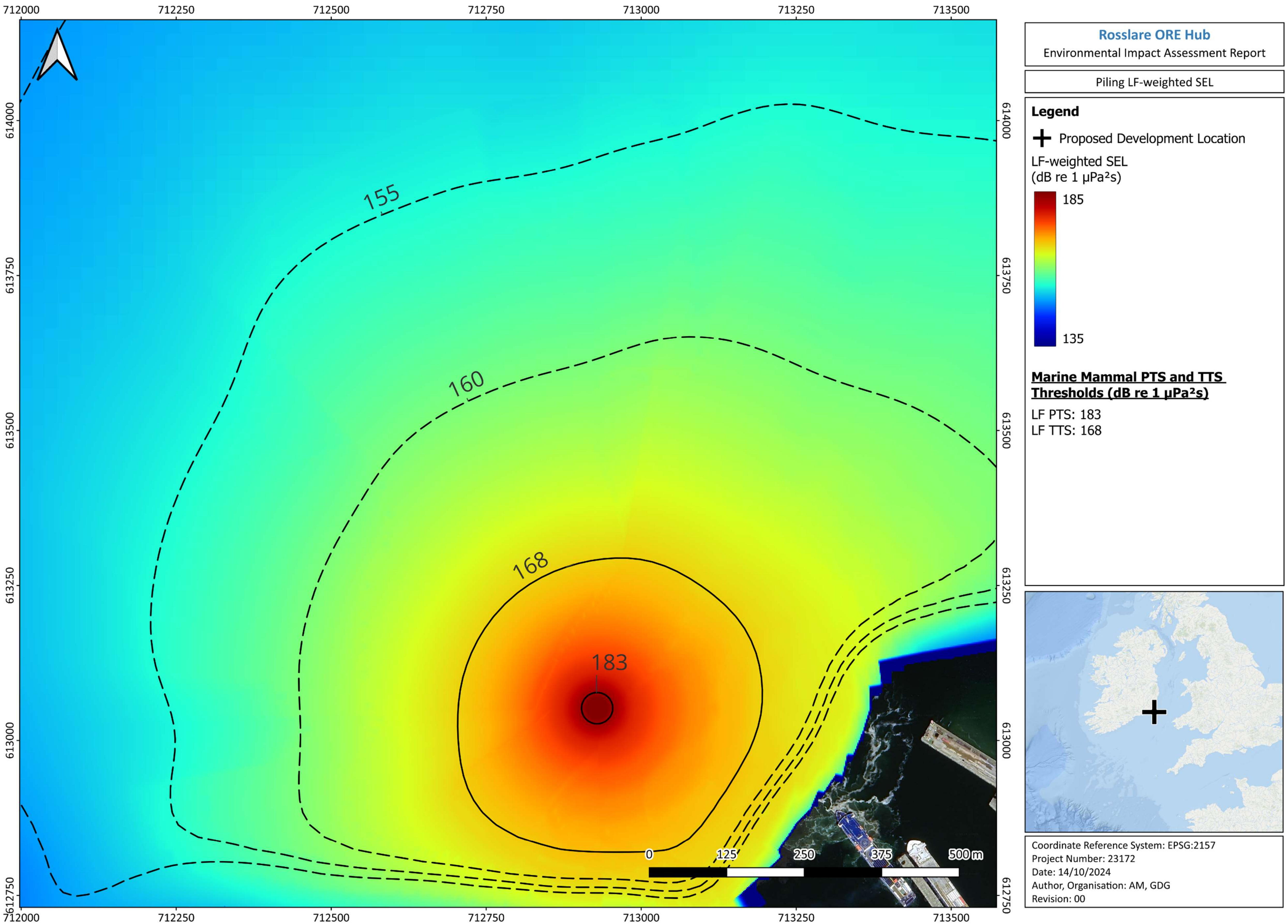

Figure 13-15: Predicted LF-weighted single-strike SEL during piling with the hammer operating at maximum energy of 240 kJ (comparison with LF hearing group PTS and TTS thresholds)

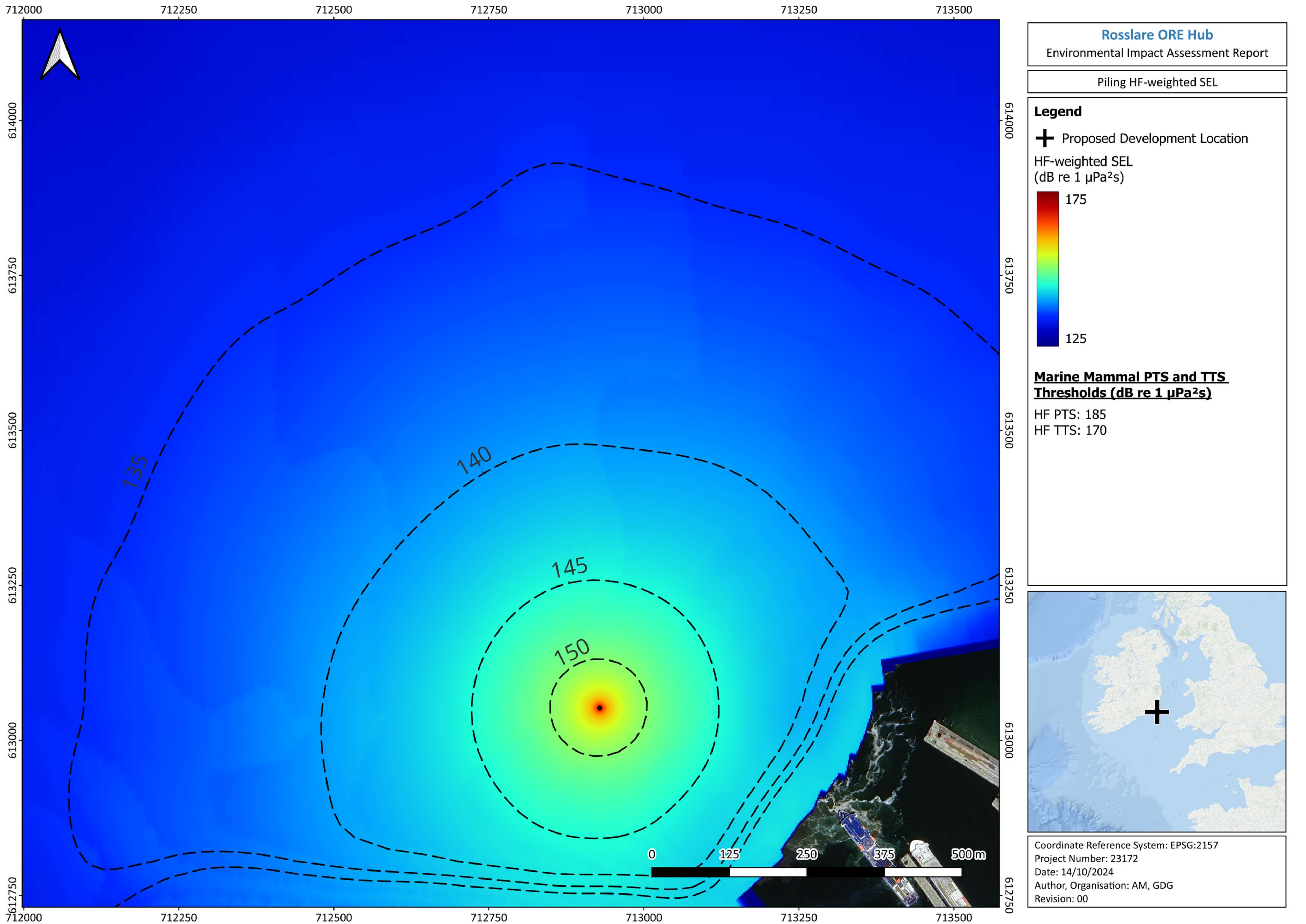

Figure 13-16: Predicted HF-weighted single-strike SEL during piling with the hammer operating at maximum energy of 240 kJ (comparison with HF hearing group PTS and TTS thresholds)

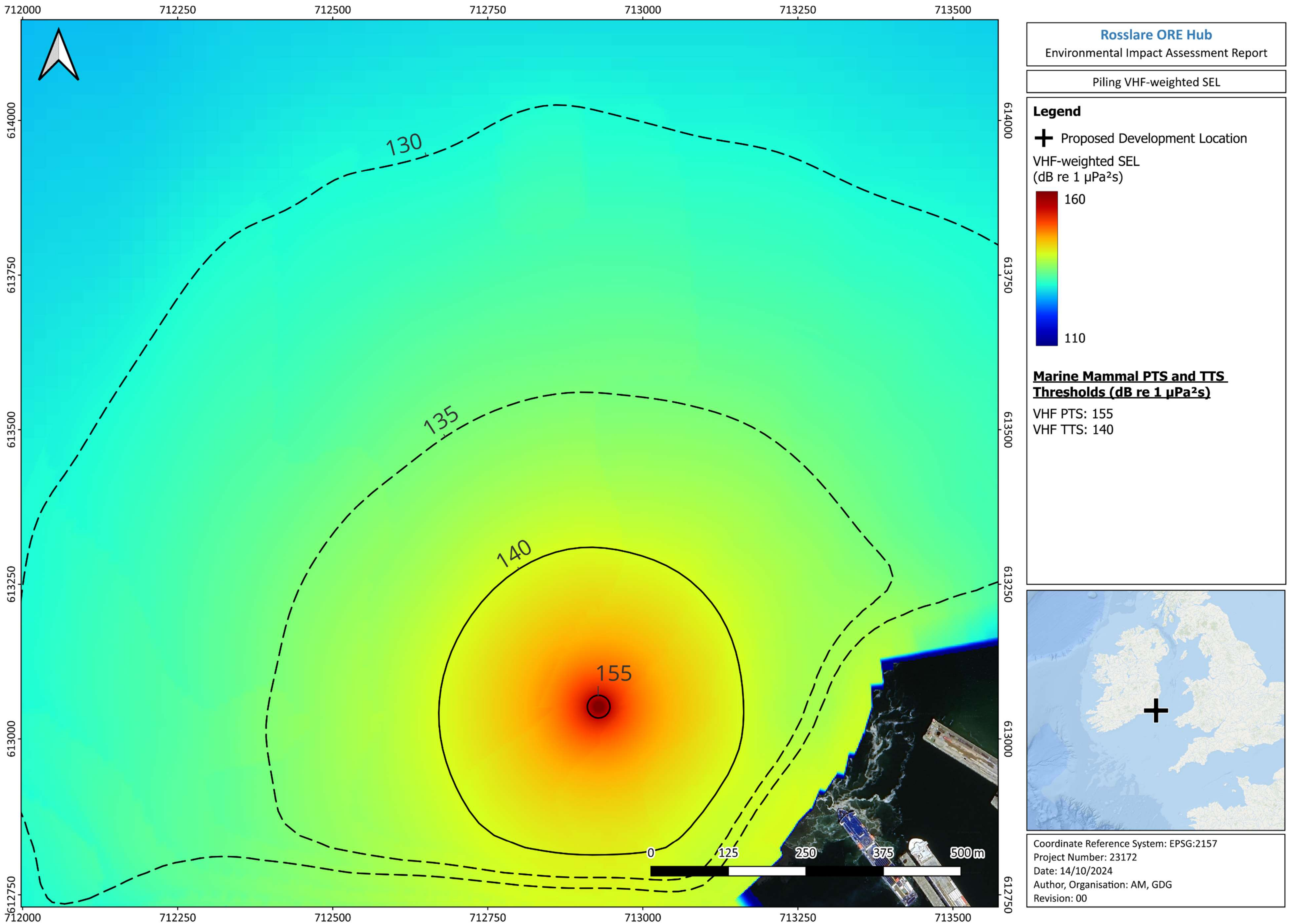

Figure 13-17: Predicted VHF-weighted single-strike SEL during piling with the hammer operating at maximum energy of 240 kJ (comparison with VHF hearing group PTS and TTS thresholds)

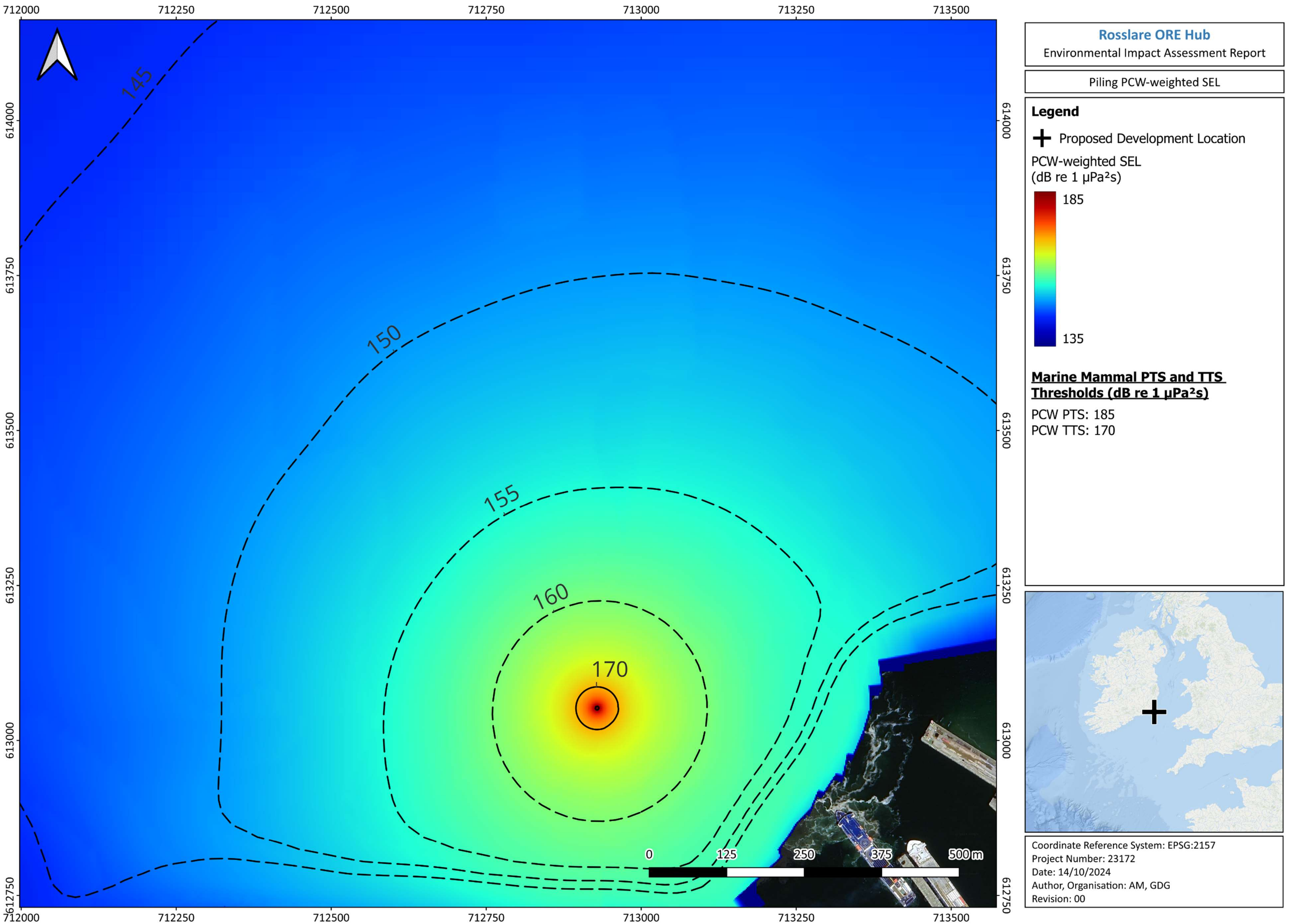

Figure 13-18: Predicted PCW-weighted single-strike SEL during piling with the hammer operating at maximum energy of 240 kJ (comparison with PCW hearing group PTS and TTS thresholds)

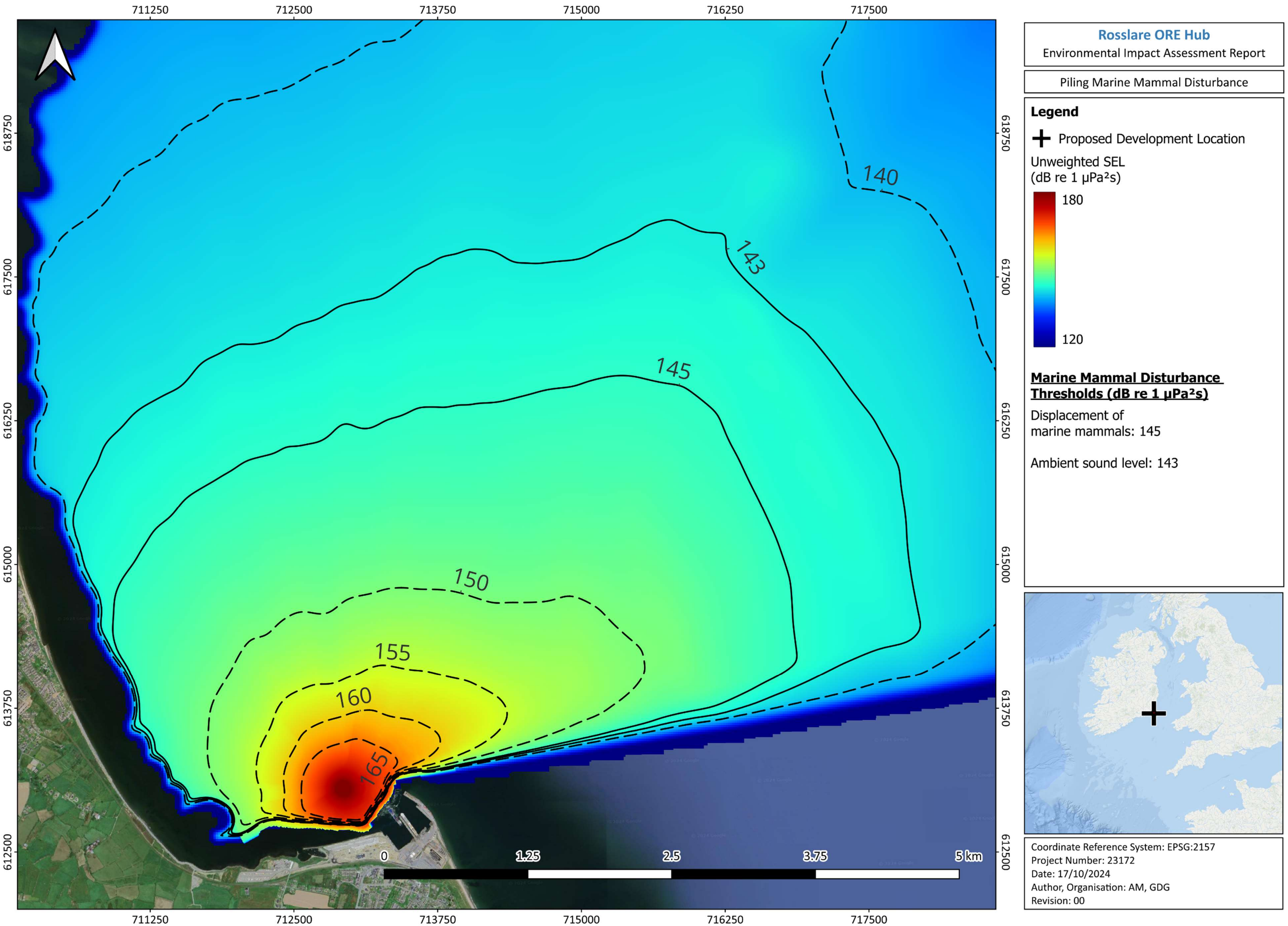

Figure 13-19: Predicted unweighted single-strike SEL during piling with the hammer operating at maximum energy of 240 kJ (comparison with marine mammal behavioural disturbance thresholds)

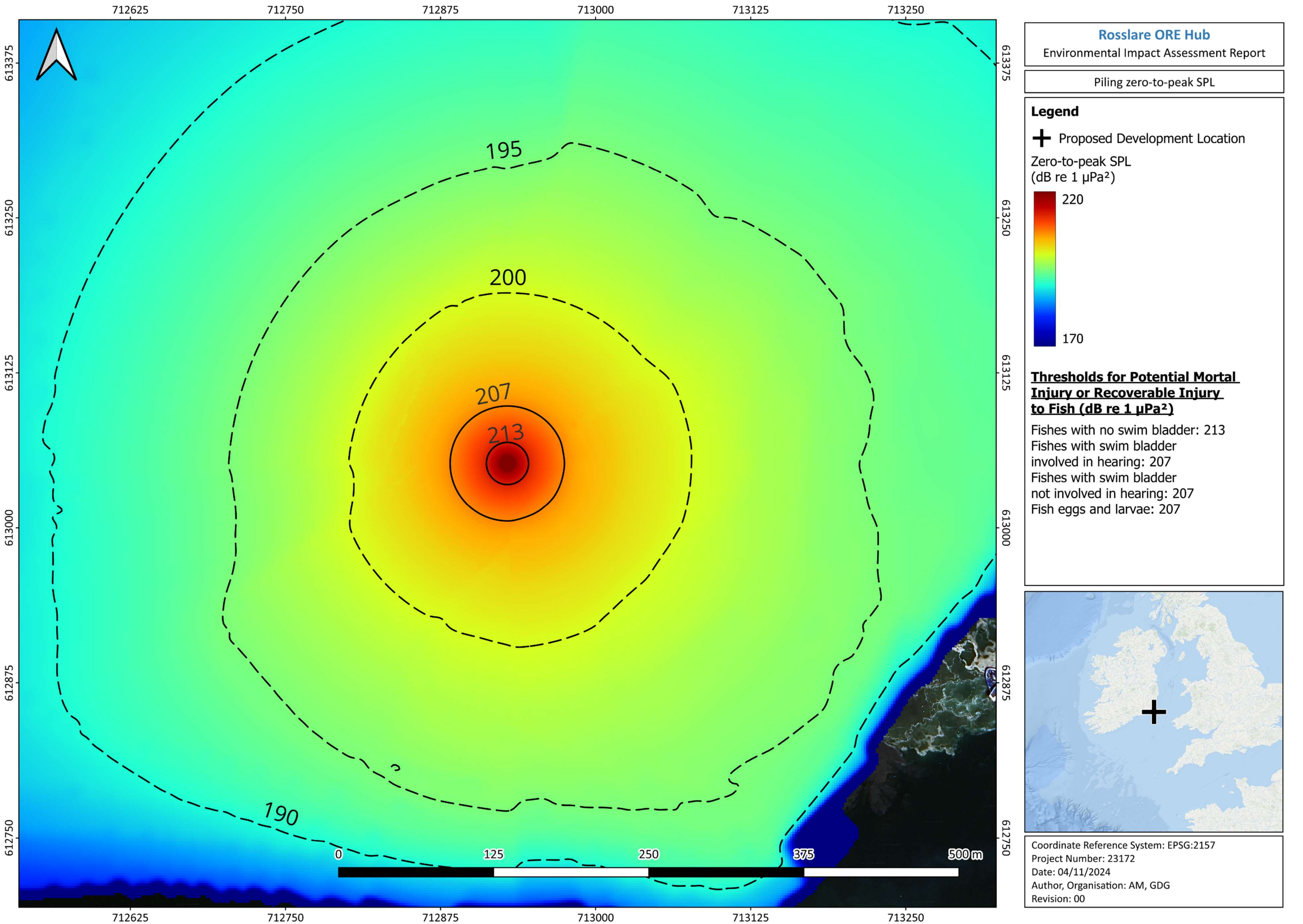

Figure 13-20: Predicted zero-to-peak SPL during piling with the hammer operating at maximum energy of 240 kJ (comparison with fish injury thresholds)

13.5.3 DREDGING

Dredging at the Proposed Development has been modelled at the location shown in Figure 13-1. This location was selected as it is the furthest location offshore that dredging will be conducted and will result in the largest areas of predicted disturbance. As a worst-case, the modelling has assumed that dredging will be conducted continuously over a 24-hour period.

13.5.3.1 MARINE MAMMALS

Permanent and Temporary Threshold Shift

The zero-to-peak SPL from dredging at the Proposed Development has been estimated and compared to the Southall *et al.* (2019) thresholds for PTS and TTS. The estimated zero-to-peak SPL during dredging is shown in Figure 13-21. The modelling predicts that the zero-to-peak SPL from dredging at the Proposed Development will not exceed the Southall *et al.* (2019) PTS and TTS thresholds (Table 13-15).

The weighted cSEL received by marine mammals was estimated following a similar methodology to that discussed previously for the piling scenario. Weighted SPLs were firstly estimated for the different hearing groups and are shown in Figure 13-22 to Figure 13-25. Marine mammals were modelled swimming away from the dredging at different swim speeds and trajectories and the weighted cSEL they received was calculated. The predicted initial distances from the dredging where marine mammals could be exposed to cSELs above the Southall *et al.* (2019) PTS and TTS thresholds for non-impulsive noise are shown in Table 13-16.

The modelling results suggest that the risk of PTS to marine mammals from the dredging operations at the Proposed Development is low. The results in Table 13-16 suggest that VHF cetaceans (e.g., harbour porpoise) that are initially within 410 m from the dredging could be exposed to cSELs above the TTS threshold if they swim away at a relatively slow speed of 1.5 m/s. This predicted distance reduces when it is assumed that they swim away from the dredging at faster swim speeds.

Table 13-15: Maximum predicted distances to zero-to-peak SPL thresholds for PTS and TTS to marine mammals from dredging

Hearing group	Zero-to-peak SPL threshold (dB re 1 μPa^2)		Maximum distance to threshold (m)	
	PTS	TTS	PTS	TTS
LF	219	213	Not exceeded	Not exceeded
HF	230	224	Not exceeded	Not exceeded
VHF	202	196	Not exceeded	Not exceeded
PCW	218	212	Not exceeded	Not exceeded

Table 13-16: Predicted distances to weighted cSEL thresholds for PTS and TTS to marine mammals from dredging

Hearing group	Swim speed (m/s)	Weighted cSEL threshold (dB re 1 µPa²s)		Distance to threshold (m)	
		PTS	TTS	PTS	TTS
LF	1.5	199	179	Not exceeded	10
	2.0			Not exceeded	10
	2.5			Not exceeded	Not exceeded
	3.0			Not exceeded	Not exceeded
HF	1.5	198	178	Not exceeded	Not exceeded
	2.0			Not exceeded	Not exceeded
	2.5			Not exceeded	Not exceeded
	3.0			Not exceeded	Not exceeded
VHF	1.5	173	153	Not exceeded	410
	2.0			Not exceeded	320
	2.5			Not exceeded	250
	3.0			Not exceeded	210
PCW	1.5	201	181	Not exceeded	Not exceeded
	2.0			Not exceeded	Not exceeded
	2.5			Not exceeded	Not exceeded
	3.0			Not exceeded	Not exceeded

Behavioural Disturbance

Disturbance to marine mammals from dredging at the Proposed Development has been estimated by comparing the predicted unweighted SPL with the adopted behavioural disturbance threshold (see Section 13.4.1.2). The adopted behavioural disturbance threshold is used to signify potential displacement of marine mammals. The predicted unweighted SPL during dredging is shown in Figure 13-26. The threshold for potential displacement of marine mammals (140 dB re 1 µPa²) is highlighted in this figure as well as the ambient rms SPL (143 dB re 1 µPa²). The ambient rms SPL provides an indication at where noise levels from the dredging can be expected to drop below ambient sound levels (i.e., provides an estimated level of audibility). It is noted that the adopted threshold for displacement is lower than the ambient rms SPL, which suggests that it is likely to be a conservative threshold for signifying displacement of marine mammals. However, during relatively quiet periods in the Proposed Development area, ambient levels will be lower than the rms SPL of 143 dB re 1 µPa^2 and displacement of some marine mammals could potentially occur at levels of 140 dB re 1 µPa^2.

The predicted maximum distances to the adopted threshold for displacement of marine mammals and the rms SPL ambient sound level are shown in Table 13-17. It is predicted that marine mammals could be displaced at distances of 1.3 km from the dredging location. As discussed previously, the threshold for displacement does not signify that all marine mammals will be displaced. There will be an increasing probability of displacement with increasing levels above the threshold. The predicted distance to the rms SPL sound level is 0.9 km. Beyond this distance, it is expected that noise from the dredging will be below ambient levels.

Table 13-17: Maximum predicted distances from dredging to the marine mammal displacement threshold and ambient rms SEL and areas impacted

Threshold	SPL (dB re 1 µPa^2)	Maximum distance (km)	Area (km^2)
Displacement of marine mammals	140	1.3	2.7
Ambient rms SPL	143	0.9	1.4

13.5.3.2 FISH

Potential impacts to fish species have been predicted by comparing the estimated zero-to-peak SPL and cSEL with the Popper *et al.* (2014) thresholds. The modelling predicts that zero-to-peak SPL during dredging will not exceed the thresholds for potential mortal injury or recoverable injury to fish species (Figure 13-27 and Table 13-18). The modelling predicts that the cSEL thresholds for potential mortal injury, recoverable injury, and TTS to fish will not be exceeded during dredging for fish that swim away at a speed of at least 1.5 m/s (Table 13-19). Injury to fish eggs and larvae that are immobile is predicted to only occur over a very limited distance from the dredging (within 10 m).

Table 13-18: Maximum predicted distances to zero-to-peak SPL thresholds for potential mortal injury or recoverable injury to fish from dredging

Fish group	Zero-to-peak SPL threshold (dB re 1 µPa^2)	Maximum distance to threshold (m)
Fishes with no swim bladder	213	Not exceeded
Fishes with swim bladder involved in hearing	207	Not exceeded
Fishes with swim bladder not involved in hearing	207	Not exceeded
Fish eggs and larvae	207	Not exceeded

Table 13-19: Predicted distances to cSEL thresholds for potential mortal injury, recoverable injury, and TTS to fish from dredging

Fish group	Swim speed (m/s)	cSEL threshold (dB re 1 µPa²s)	Distance to threshold (m)
Potential mortal injury			
Fishes with no swim bladder	1.5	219	Not exceeded
Fishes with swim bladder involved in hearing	1.5	210	Not exceeded
Fishes with swim bladder not involved in hearing	1.5	207	Not exceeded
Fish eggs and larvae	Stationary	210	10
Recoverable injury			
Fishes with no swim bladder	1.5	216	Not exceeded
Fishes with swim bladder involved in hearing	1.5	203	Not exceeded
Fishes with swim bladder not involved in hearing	1.5	203	Not exceeded
Fish eggs and larvae	Stationary	N/A	N/A
TTS			
Fishes with no swim bladder	1.5	186	Not exceeded
Fishes with swim bladder involved in hearing	1.5	186	Not exceeded
Fishes with swim bladder not involved in hearing	1.5	186	Not exceeded
Fish eggs and larvae	Stationary	N/A	N/A

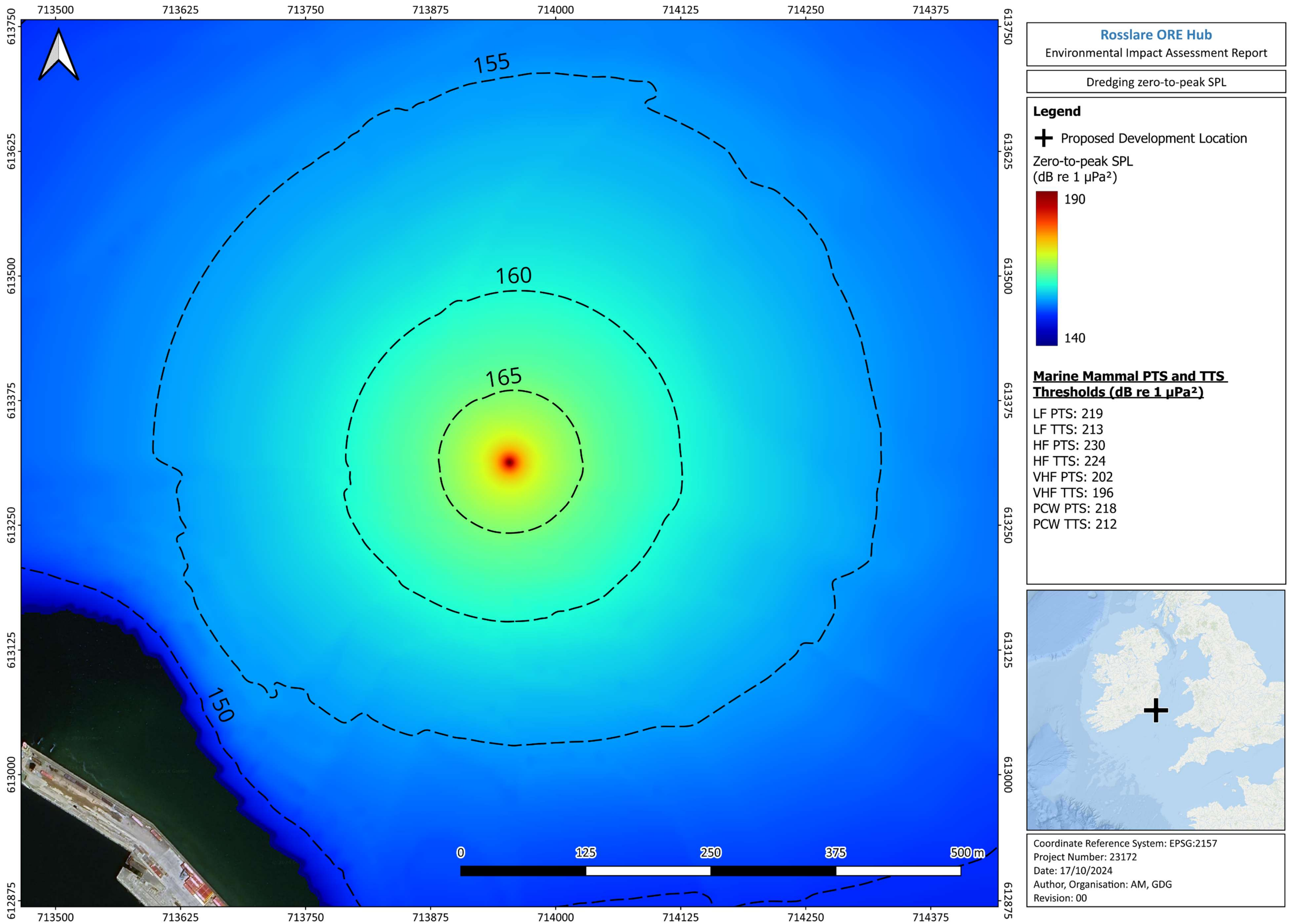

Figure 13-21: Predicted zero-to-peak SPL during dredging (comparison with marine mammal PTS and TTS thresholds)

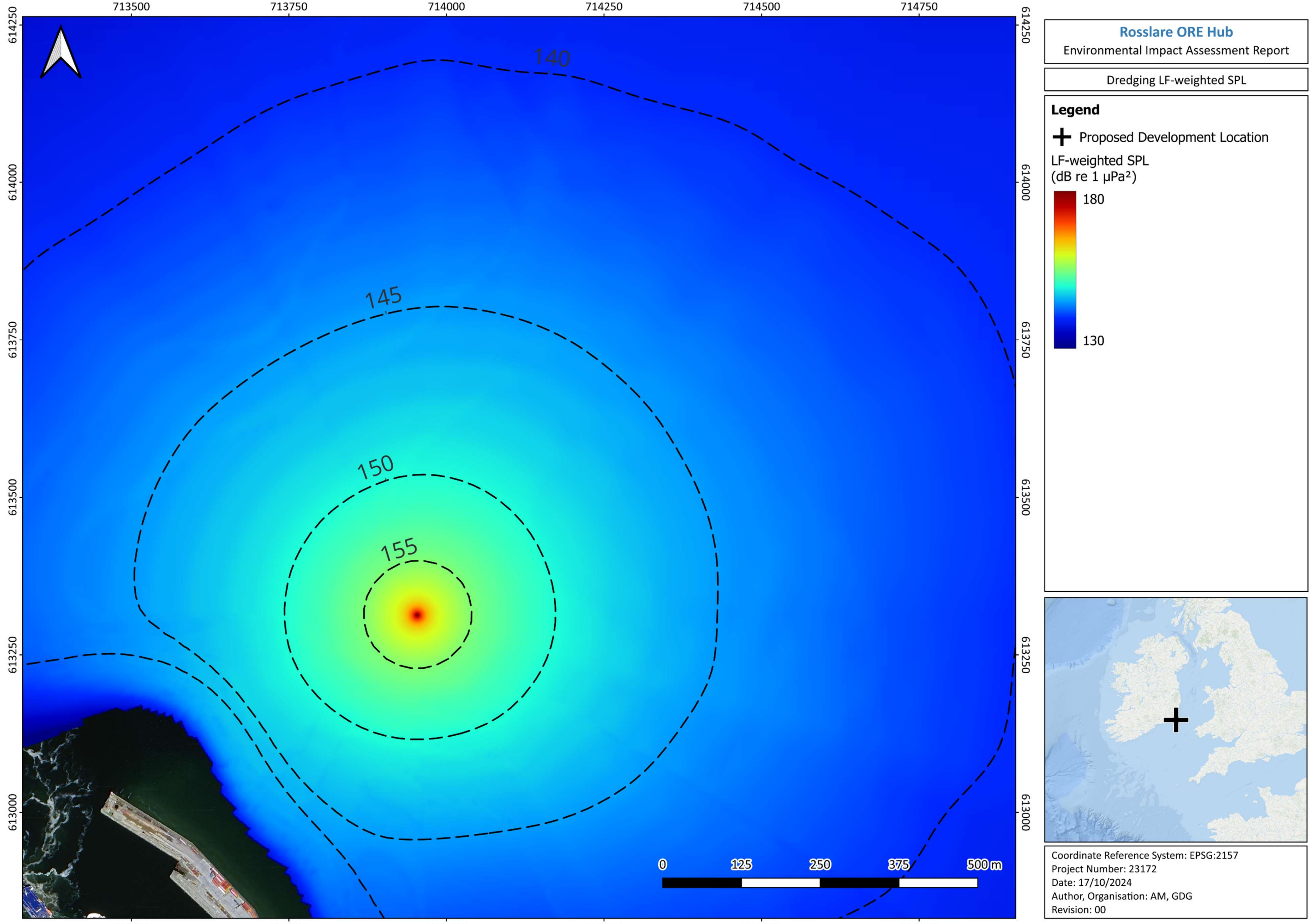

Figure 13-22: Predicted LF-weighted SPL during dredging

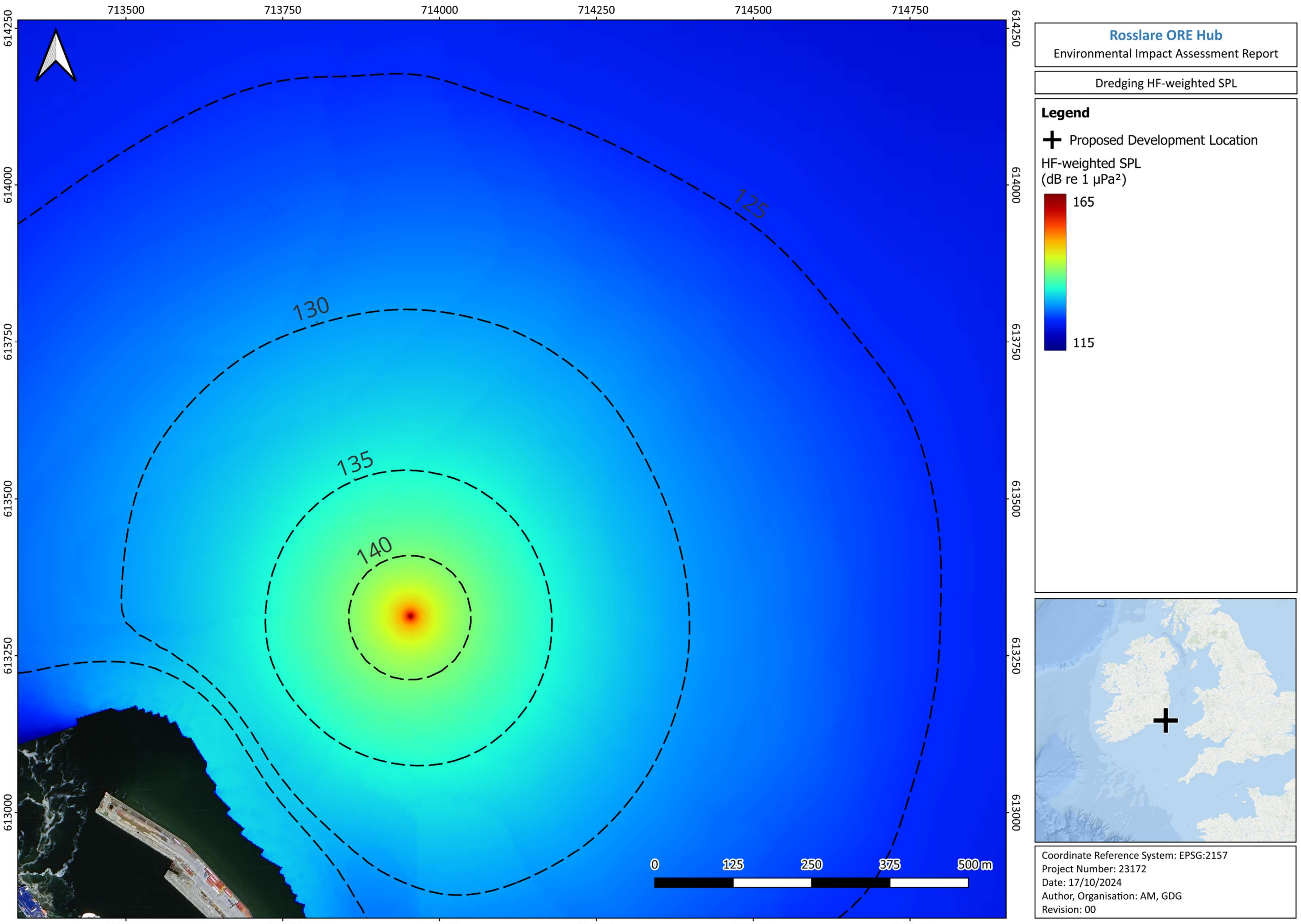

Figure 13-23: Predicted HF-weighted SPL during dredging

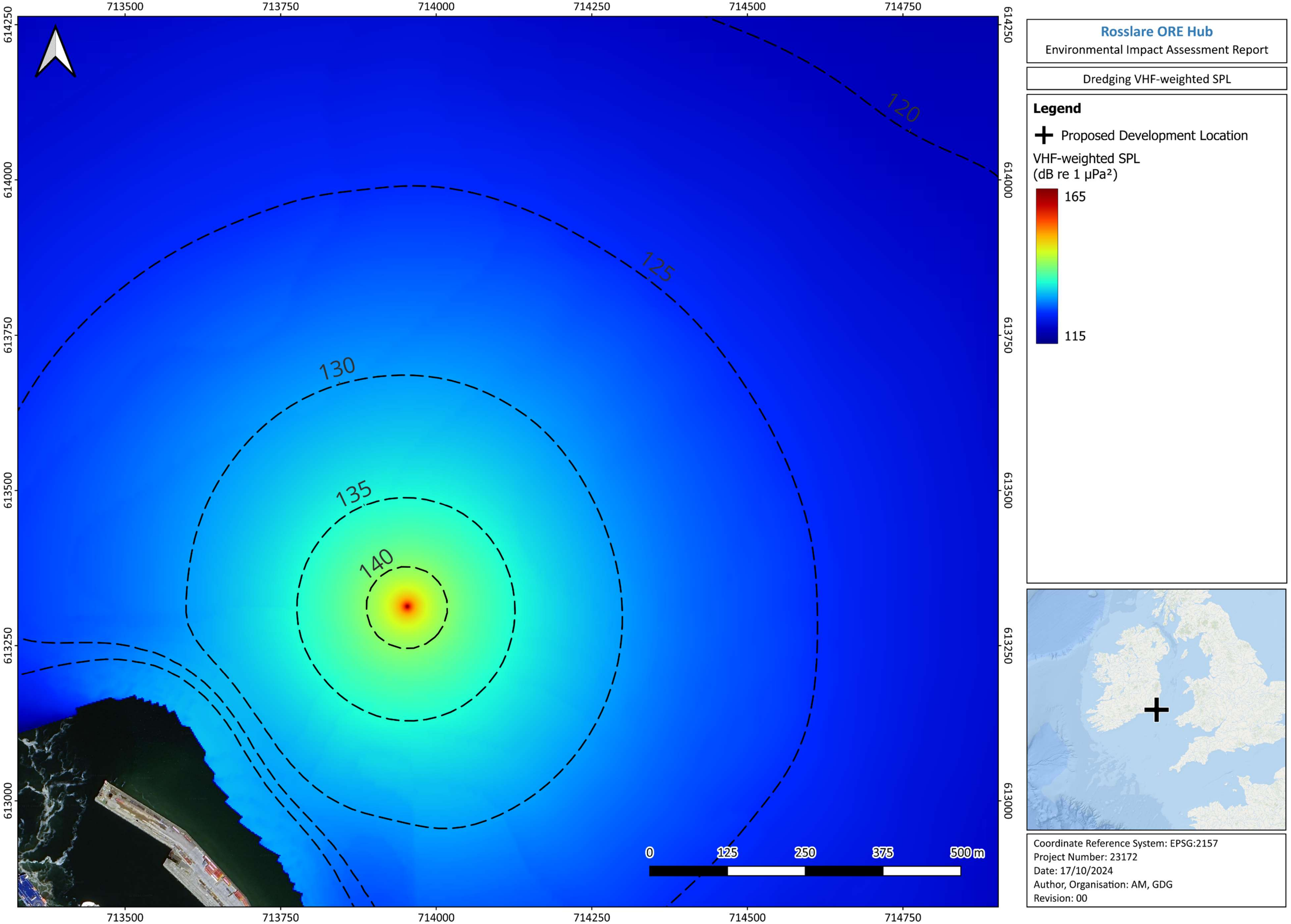

Figure 13-24: Predicted VHF-weighted SPL during dredging

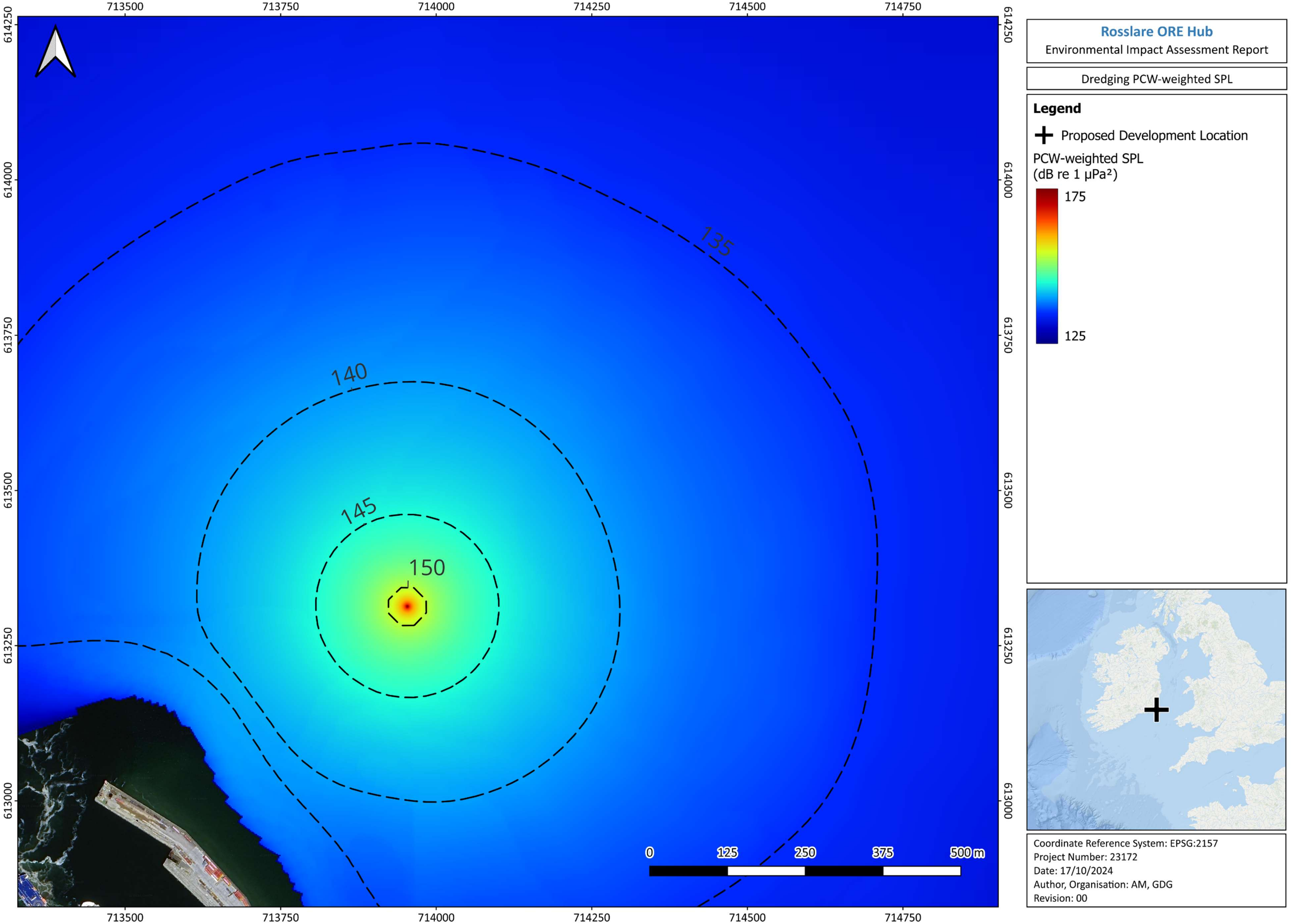

Figure 13-25: Predicted PCW-weighted SPL during dredging

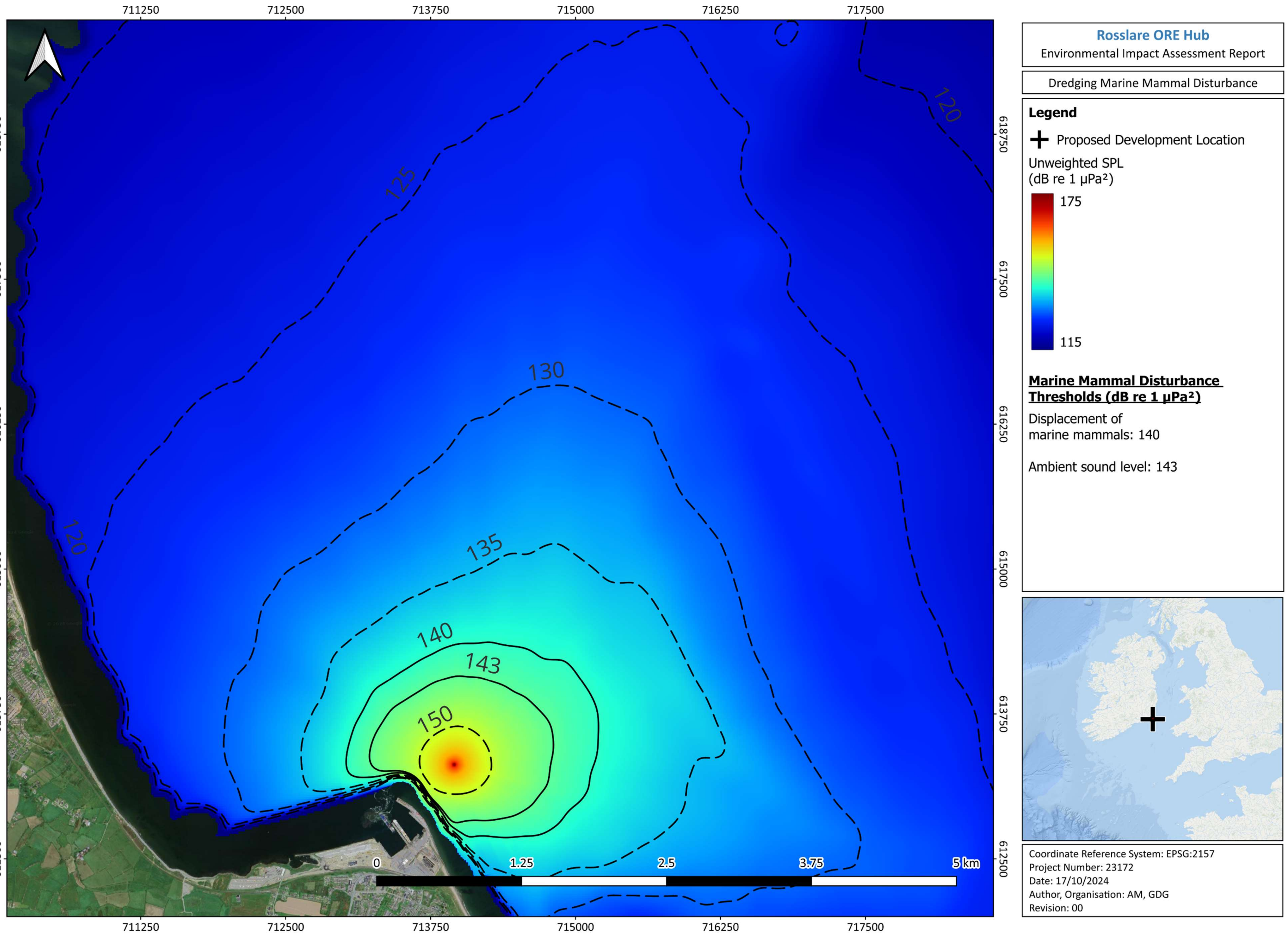

Figure 13-26: Predicted unweighted SPL during dredging (comparison with marine mammal behavioural disturbance thresholds)

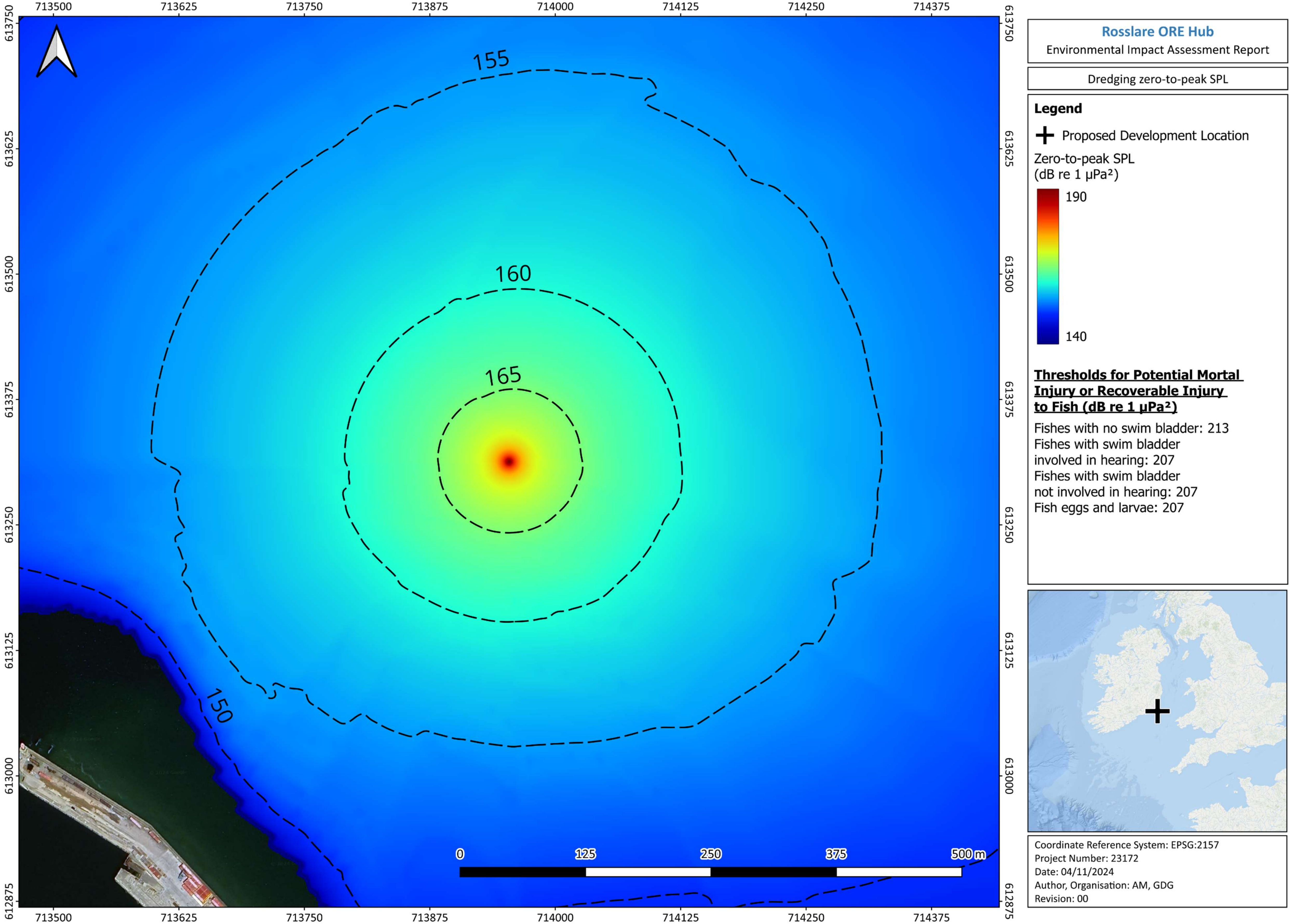

Figure 13-27: Predicted zero-to-peak SPL during dredging (comparison with fish injury thresholds)

13.5.4 BLASTING

The zero-to-peak SPL from potential blasting at the Proposed Development has been calculated using the semi-empirical model discussed in Section 13.3.2.2. Each blasting event will involve 50 kg of explosive placed in pre-drilled holes and detonated sequentially with a small-time delay between individual detonations. The time delay is such that the zero-to-peak SPL from the resulting waveform will be the same as that from a single individual detonation. The zero-to-peak SPL has been estimated with lower and upper bounds as discussed in Section 13.3.2.2. This provides a range of estimated distances where potential impacts could occur. It is expected that only one blasting event will be conducted on any given day and there will be 2 – 3 weeks between successive blasting events. As such, the blasting is not expected to cause significant disturbance. Therefore, the following assessment only considers the potential for the rock blasting to cause auditory injury to marine mammals and injury to fish species.

13.5.4.1 MARINE MAMMALS

The predicted zero-to-peak SPL during rock blasting at the Proposed Development is shown in Figure 13-28 in relation to the marine mammal PTS and TTS thresholds. The predicted ranges where the PTS and TTS could potentially be exceeded during rock blasting at the Proposed Development are summarised in Table 13-20. The bold highlighted numbers in Table 13-20 indicate the predicted distances to threshold exceedance based on the zero-to-peak sound pressure calculated according to equation (38), whilst the bracketed numbers indicate the predicted distances to threshold exceedance when the zero-to-peak sound pressure is calculated according to the lower and upper bounds given by equations (39) and (40).

The results in Table 13-20 indicate that PTS to marine mammals could occur from the rock blasting but is likely to be relatively limited for marine mammals belonging to the LF hearing group (e.g., minke whales), HF hearing group (e.g., dolphins), and PCW hearing group (e.g., seals). The predicted distances to the PTS thresholds for all these hearing groups are all less than the standard 1 km mitigation zone suggested by DAHG (2014). Therefore, PTS for these hearing groups can be effectively mitigated with standard mitigation techniques (such as MMOs monitoring a 1 km mitigation zone and delaying blasting if marine mammals are observed within the mitigation zone). TTS to marine mammals belonging to these hearing groups is also likely to be effectively mitigated if standard mitigation measures are followed. However, the modelling suggests that PTS and TTS to the VHF hearing group (e.g., harbour porpoise) could occur over larger distances exceeding 1 km that may be difficult to fully mitigate against without the use of noise reduction measures (such as bubble curtains).

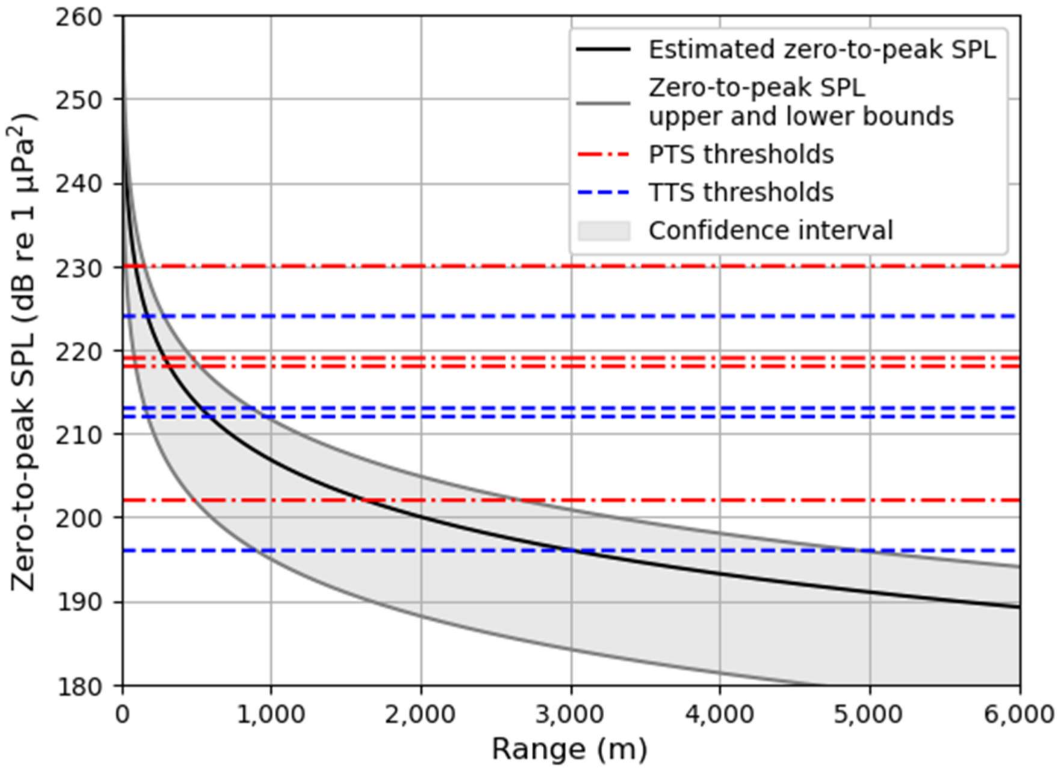

Figure 13-28: Predicted zero-to-peak SPL during rock blasting (comparison with marine mammal PTS and TTS thresholds)

Table 13-20: Predicted distances to zero-to-peak SPL thresholds for PTS and TTS to marine mammals from rock blasting

Hearing group	Zero-to-peak SPL threshold (dB re 1 µPa²)		Maximum distance to threshold (m) [1]	
	PTS	TTS	PTS	TTS
LF	219	213	**290** (85 - 470)	**520** (160 - 870)
HF	230	224	**95** (30 - 155)	**170** (50 - 285)
VHF	202	196	**1,630** (490 – 2,670)	**3,000** (900 – 4,920)
PCW	218	212	**320** (95 - 525)	**590** (175 - 965)

[1] **Bold** highlighted numbers indicate the predicted distances to threshold exceedance whilst the numbers in brackets indicate predicted lower and upper bounds.

13.5.4.2 FISH

The predicted zero-to-peak SPL in relation to the fish injury thresholds is shown in Figure 13-29. The predicted ranges where the fish injury thresholds could be exceeded are summarised in Table 13-21.

The modelling results suggest that injury to fish species will be limited to ranges less than 170 m from the blasting location.

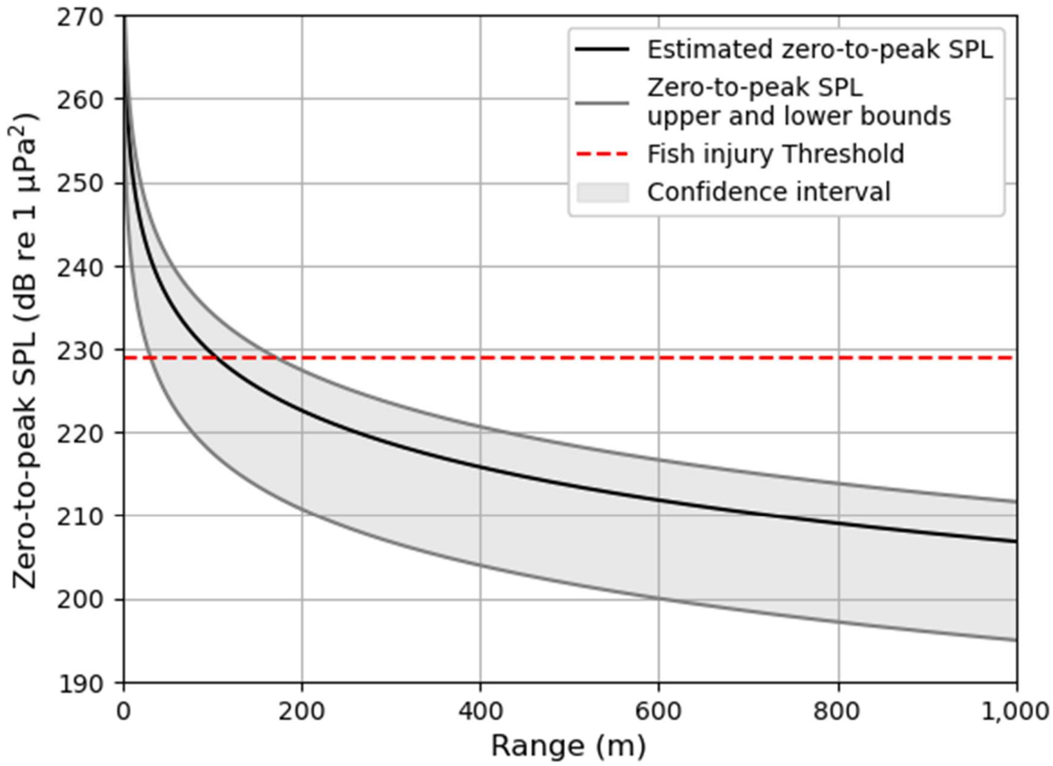

Figure 13-29: Predicted zero-to-peak SPL during rock blasting (comparison with fish injury thresholds)

Table 13-21: Predicted distances to zero-to-peak SPL thresholds for injury to fish from rock blasting

Fish group	Zero-to-peak SPL threshold (dB re 1 µPa²)	Maximum distance to threshold (m) [1]
Fishes with no swim bladder	229	**105** (30 - 170)
Fishes with swim bladder involved in hearing	229	**105** (30 - 170)
Fishes with swim bladder not involved in hearing	229	**105** (30 - 170)
Fish eggs and larvae	229	**105** (30 - 170)
[1] **Bold** highlighted numbers indicate the predicted distances to threshold exceedance whilst the numbers in brackets indicate predicted lower and upper bounds.		

13.6 CONCLUSIONS

This Technical Report has presented underwater noise modelling results for assessing potential impacts that piling, dredging, and rock blasting activities at the Proposed Development could potentially have on marine mammals and fish that may be present in the area. Potential impacts to marine mammals were estimated by comparing predicted noise levels with the Southall *et al.* (2019) thresholds for PTS and TTS, whilst potential impacts to fish species estimated by comparing predicted noise levels with the Popper *et al.* (2014) thresholds for injury.

The modelling results suggest that the risk of PTS to marine mammals from piling at the Proposed Development is likely to be low and can be appropriately mitigated against using standard mitigation measures (e.g., MMOs monitoring a suitable mitigation zone and delaying piling activities until all marine mammals have vacated the mitigation zone). TTS to marine mammals belonging to the LF hearing group (e.g., minke whales) and VHF hearing group (e.g., harbour porpoise) from piling may occur over larger distances (predicted up to 2.6 km) if they slowly move away from the piling location. It was estimated that displacement of marine mammals could occur out to a maximum distance of 4.6 km from the piling location. Potential injury to fish species during piling is predicted to be very limited and confined to within 50 m of the piling location.

Dredging at the Proposed Development is not expected to result in PTS to any marine mammals due to the relatively low levels of noise that are generated. The modelling results also suggest that the risk of TTS to any marine mammals will be low and can be effectively mitigated against using standard mitigation measures. The modelling results suggest that displacement to marine mammals during dredging could potentially occur out to 1.3 km. It is predicted that the dredging will not result in injury to any fish species.

Rock blasting at the Proposed Development could potentially result in the highest noise levels compared to other activities and could therefore potentially have the greatest impact in terms of auditory injury to marine mammals and injury to fish species. However, the modelling results suggest that PTS to marine mammals belonging to the LF hearing group (e.g., minke whales), HF hearing group (e.g., dolphins), and PCW hearing group (e.g., seals) will be limited to within a maximum distance of 525 m and can be suitably mitigated with MMOs observing an appropriate mitigation zone (e.g., DAHG (2014) guidance suggests a 1 km mitigation zone for the use of explosives). The risk of TTS to these species can also be effectively mitigated following standard mitigation techniques. The modelling suggests that PTS and TTS to marine mammals belonging to the VHF hearing group (e.g., harbour porpoise) could occur over larger distances with estimated distances to PTS threshold exceedance ranging from 490 – 2,670 m and estimated distances to TTS threshold exceedance ranging from 900 – 4,920 m. Standard mitigation measures may therefore not be completely effective in mitigating the risk of PTS and TTS to harbour porpoise during rock blasting.

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